

Virginia Department of Environmental Quality
Draft 2016 Water Quality Integrated Report
Public Comment – Response Document

Comments received
August 7, 2017 to September 6, 2017

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Comments from EPA Region III



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
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Philadelphia, Pennsylvania 19103-2029

Ms. Sandra Mueller
Office of Water Monitoring and Assessment
Virginia Department of Environmental Quality
P.O. Box 1105
Richmond, Virginia 23218-1105

SEP 06 2017

Dear Ms. Mueller:

Thank you for the opportunity to review the Virginia Department of Environmental Quality's (VADEQ) *Draft 2016 305(b)/303(d) Water Quality Assessment Integrated Report (IR)*. The U.S. Environmental Protection Agency (EPA) is providing comments related to specific impaired waterbody segments and proposed delistings in the enclosure. EPA has also outlined additional comments below.

TMDL Priority List

VADEQ transitioned from a TMDL priority list that set a target year for TMDL development, which was used for 2014 and prior 303(d) lists, to a High (H), Medium (M), and Low (L) TMDL priority development ranking system in the 2016 IR. The narrative portion of the Integrated Report should define and explain the meaning of High, Medium, and Low priority rankings. In addition, the priority ranking explanation needs to clearly identify which waters are targeted for TMDL development in the next two years. 40 CFR Part 130.7(b)(4). EPA's understanding of the new ranking is the "H" priority signifies the water is targeted for TMDL development in the next two years, "M" signifies the water is targeted for TMDL development by 2022, and "L" signifies the water is targeted for TMDL development after 2022. Please clarify. Additionally, the title of this column is "TMDL Revision Priority." Should this column be labeled as "TMDL Development Priority"?

Shenandoah River Algae

EPA acknowledges and appreciates the efforts that VADEQ staff have put forth to meet Shenandoah River related algae commitments affirmed by VADEQ in your April 18, 2016 letter to EPA. In 2016, VADEQ spent a significant amount of staff resources testing and evaluating potential field methods for measuring filamentous algal growth. EPA also commends VADEQ for creating a website and hosting a webinar to inform the public of Shenandoah River algae progress. EPA looks forward to reviewing VADEQ's final field methodology and attainment

threshold during the public comment period for Virginia's 2018 *Water Quality Assessment Guidance Manual*.

As noted in EPA's *Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act* (2006 IRG), states "may set a reasonable "cutoff" date after which no additional data or information will be considered in the preparation of the draft 303(d) list." EPA considers the period of record established by VADEQ (January 1, 2009 to December 31, 2014) for the draft 2016 303(d) list to be reasonable. However, nothing in Clean Water Act Section 303(d) and EPA's implementing regulations preclude VADEQ from exercising its discretion to consider data past the cutoff date if deemed appropriate. Notwithstanding the 2016 IR data cutoff, nothing in federal law precludes VADEQ from considering any Shenandoah River data and information collected by VADEQ staff after the 2016 IR data cutoff, as well as information submitted by the Shenandoah Riverkeeper during the 2014 IR cycle, to see if sufficient data are available to make a recreation use assessment decision on any Shenandoah River segments for the final 2016 IR. For example, EPA notes that VADEQ's 2016 benthic algal monitoring data collected at the North Fork Shenandoah River at Timberville and North Fork Shenandoah River at Strasburg appear to reflect algal growth during September and October.

To support VADEQ's determination to list or not list a waterbody, please provide a rationale for any decision to not use any existing and readily available information that predates the data cutoff. 40 CFR Part 130.7(b)(6)(iii). As discussed above, a reasonable cutoff date is an appropriate rationale to not use any existing and readily available data.

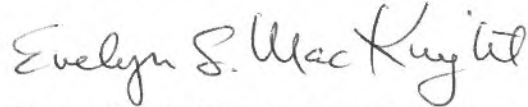
EPA notes VADEQ's description of public concerns and comments on Shenandoah algae issues and VADEQ's efforts to address the issues in chapter 4.3 of Virginia's draft 2016 IR. EPA recommends that VADEQ provide further explanation of the statement that "more data is needed before decisions on recreation use impacts can be made." In particular, it would be useful for VADEQ to provide additional detail regarding:

1. What additional data/information VADEQ anticipates obtaining to assess Virginia's narrative criteria with respect to excess algae;
2. How input from the public/water users will be used to develop an algal assessment threshold; and
3. How third party data/information related to excess algal growth will be used and evaluated in the future.

EPA also recommends that VADEQ explain if/how it will incorporate any public opinion related to algal growth in the development of a future attainment threshold for recreation use assessments, which is to be released in the State's 2018 IR Guidance.

EPA appreciates the continued cooperation from VADEQ staff in evaluating the water quality issues in the Commonwealth. If you have any questions, please feel free to contact Jon Markovich at markovich.jonathan@epa.gov or (215) 814-5784.

Sincerely,

A handwritten signature in cursive script that reads "Evelyn S. MacKnight".

Evelyn S. MacKnight, Associate Director
Office of Standards, Assessment and TMDLs

Enclosure

General 303(d) List Comments:

Mileage Discrepancies: EPA requests clarification on mileage discrepancies between the 2014 and 2016 lists for the following waterbodies (miles/acres/sq. miles).

Cause Group Code(s)	2016 Listing	2014 Listing
A05R-02-BEN	4.76	6.19
A15L-01-HG	73.93	74.07
A15L-01-PCB		
B31L-01-PH	10.84	11.44
G01E-03-PCB	183.259	192.222
G12L-02-DO	489.49	489.61
G12L-02-TP		
G14L-03-DO	715.37	715.52
I16R-01-PH	4.85	5.16
L60R-01-HG	1655.18	1655.41
L60R-01-PCB		
M02L-01-DDD		
M02L-01-DDE	42.46	42.69
M02L-01-DDT		
M02L-01-HG		
K23R-05-BAC	27.71	28.02
K28R-05-BAC	4.22	4.62
K28R-05-DO	36.91	37.02
	26.81	26.91
K32R-13-HG	701.67	701.82
	611.63	611.81
Q09R-01-BAC	8.87	9.29
C01E-17-PCB	1825.564	1825.733
C07E-33-EBEN	0.248	0.364
F07L-01-PCB	7468.77	7469.59
N06R-03-BAC	5.38	7.48

Specific Impairments:

Cause Group Code O10R-01-PCB: On the 2014 303(d) list, there is a North Fork Holston River Fish Consumption - PCB in fish tissue impairment for 13.44 miles first listed in 2010. On the 2016 303(d) list, it appears the 13.44 mile impaired segment was split and now shows two impaired segments: 4.92 miles, first listed in 1996, and 8.52 miles, first listed in 2010. Please explain.

The following are waterbody impairments on the 2014 303(d) list not on the 2016 303(d) list, for which EPA could not find a delisting rationale or supporting materials. Should these be included

on the 2016 303(d) list? If not, please provide a rationale or supporting information for delisting of these segments.

Cause Group Code	2014 303(d) List
G01E-03-PCB	0.003 sq. miles first listed in 2010, PCBs
Q12R-04-BAC	3.82 miles first listed in 2012, <i>E. coli</i>
C07E-04-BAC2	0.121 sq. miles first listed in 2010, <i>Enterococcus</i>
N37R-02-DO	8.30 miles first listed in 2010, Dissolved Oxygen

Comments on Delisting Materials:

Cause Group Code I30R-02-BAC: This 303(d) ID was listed on the 2014 303(d) List as "Mill Creek" based off an assessment of fecal coliform (2.08 miles) in 2006 and *Escherichia coli* (2.08 miles) in 2008. In 2016, this Cause Group Code was listed as "Hamilton Branch" based off one assessment of *Escherichia coli* (6.28 miles) in 2016. Based on the Delist data, Mill Creek should be removed from the 303(d) List. Why was Hamilton Branch added with the same Cause Group Code? Please clarify.

Proposed 4C Waterbodies

Lakes: For each of the four lakes proposed for 4C classification, EPA recommends additional analysis and justification to determine the appropriateness of reclassifying as 4C. VADEQ's assessment methodology suggests placing a lake impaired for dissolved oxygen (DO) in category 4C if the lake is meeting nutrient/Chlorophyll-a criteria (§187 Lakes-only) and that the source of impairment is other than nutrients. Category 4C is intended for waterbodies where a pollutant is not causing impairment. EPA recommends the 4C lake candidates remain in category 5 until the source of DO impairment is determined not to be a pollutant. Specific concerns are outlined below.

1. Stonehouse Creek Reservoir: Surrounding land-use is agriculture (hay/pasture) and adjacent stream segments are impaired by *E. coli*. These characteristics do not suggest the impairment is not caused by a pollutant (category 4C).
2. Cherrystone Reservoir: Surrounding land-use is agriculture (hay/pasture) and adjacent stream segments are impaired by *E. coli*. These characteristics do not suggest the impairment is not caused by a pollutant (category 4C).
3. Roaring Fork Reservoir: Surrounding land-use is agriculture (hay/pasture) and adjacent stream segments are impaired by *E. coli*. The waterbody is also impaired for pH with unknown sources. These characteristics do not suggest the impairment is not caused by a pollutant (category 4C).

Swampwaters:

1. Kingsland Creek: As stated in the natural conditions report, the surrounding land-use in the Kingsland Creek watershed is predominantly urban. VADEQ's natural condition assessment methodology calls for determination

of anthropogenic impacts and highlights that land use analysis is a valuable tool for identifying potential human impacts. Although the report noted that forested buffers protect the creek from urban influence, the additional impairment of *E. coli* could suggest otherwise. In addition, EPA reminds VADEQ that the USGS 1999 background nutrient values used to support natural conditions assessments were updated by USGS in 2010. If nutrients continue to be evaluated for identifying potential human impacts, the updated 2010 values could be used while VADEQ works to update its natural condition methodology. Additionally, the methodology states that the impacts of acid rain should be considered for low pH waters. Was acid rain considered? The natural conditions report identifies that there is one active permitted point source discharger in the Kingsland Creek watershed. EPA notes that Chesterfield County holds a Phase I MS4 permit and lists Kingsland Creek as a waterbody receiving stormwater discharges. This is not included or discussed in the natural conditions report. Based on reasons mentioned above, more information is needed to conclude whether or not anthropogenic sources are causing impairment, and Kingsland Creek should remain in category 5.

2. *Airfield Pond Cause Group Code K35L-01-DO*: EPA understands that Airfield Pond will be re-listed in Category 5 for Dissolved Oxygen on the final 2016 303(d) list. Please confirm.

4B-5E Facility Delistings

1. VA0088102: It appears that no monitoring data was provided for total recoverable zinc. Please clarify.
2. VA0088463: DMR lists the maximum pH limit as 9.0; whereas, the limit should be 8.0, correct?
3. VA0073318, VA0024121, and VA0062880: Virginia's criteria for metals are based on equations that include a WER multiplier, and were previously approved for CWA purposes. To reflect the latest scientific knowledge on metals speciation and bioavailability, EPA updated its national recommended aquatic life criteria for copper to include a new means of quantifying copper toxicity and to utilize a more advanced modeling approach for developing water quality criteria. This update incorporates the use of the Biotic Ligand Model (BLM) in the criteria derivation procedures. In Virginia's recent Water Quality Standard (WQS) Triennial Review, VADEQ included a copper BLM that will apply on a case-by-case basis. And correspondingly, Virginia added the BLM option for copper criteria. EPA recommends that Virginia consider, to the extent feasible, incorporating BLM input parameters into their statewide monitoring efforts. The additional monitoring will ensure that data are available as Virginia considers the BLM in future WQS Triennial Reviews. For more information on the BLM input parameters. See <https://www.epa.gov/wqc/aquatic-life-criteria-copper>.

4. VA0003867: EPA is concerned that the increased number of seagulls surrounding the facility is likely due to the presence of the discharger's facility processes/operations. Measures to reduce the presence of seagulls and their negative impacts on water quality near the facility should be taken.
5. VA0005215: Permit lists "total residual chlorine" instead of "total recoverable chlorine". Please explain.
6. VA0089982: Why is it appropriate to remove the total recoverable limits for zinc and copper even though monitoring data shows non-compliance? Although monitoring for dissolved metals and WET testing will occur, a limit may still necessary to maintain water quality. Please explain.

Waterbody Delistings – Rationales and Data Files

1. VAV-B40R_GRS01A10 for Aquatic Life: The VRO Delist package lists the stream size as 3.46 miles; whereas 3.64 is listed on the master spreadsheet. Please clarify.
2. VAV-B56R_CRO01A00 for Aquatic Life: What is the river mile location of the original listing station 1BCRO-CRO1-FOSR?
3. VAV-B57R_RSC01A00 for Aquatic Life: Table in VRO Delist package lists this as a partial delisting. Is this correct? If so, what is the remaining impairment size/pollutant?
4. VAP-A32R_NOM02A14 for Aquatic Life: Could not find data, please provide.
5. VAN-E14R_ROB01A06 for Recreation: Could not find data, please provide.
6. VAP-E26E_MEA03A10 for Recreation: Please explain why DO was used to judge attainment with recreation designated use.
7. VAP-F13R_TPT01A98 for Aquatic Life: Data sheet only lists data for one of six listed monitoring stations, please provide data for additional monitoring stations.
8. VAT-C07E_NWB01B08 for Shellfishing: Could not find data, please provide.
9. VAT-C07E_WHH01A06 for Recreation: Third party collected data to demonstrate high *E. coli*, but because the WQS is based on *Enterococci*, VA is delisting the segment as "insufficient data". Water quality data should be used to determine a waterbody is no longer impaired. EPA suggests the segment remain on Category 5 until *Enterococci* data are collected and evaluated.
10. VAT-D03R_GAR01A02 for Aquatic Life: Please explain the seasonal effects impacting spring IBI scores. The average IBI score is 39.6, which is below the threshold of 40. Additionally, please explain why IBI scores are averaged. VADEQ's assessment guidance (page 25) notes that averaging IBI scores would "weaken the ability to accurately predict current conditions".
11. VAC-H35R_LWW01A08 for Aquatic Life: The data sheets show *E. coli* data, but the spreadsheet lists DO as the parameter. Please clarify.
12. VAP-H34R_RSM01A08 for Aquatic Life: Could not find data, please provide.
13. VAP-H39R_XUT01A04 for Aquatic Life: Could not find data, please provide.
14. VAP-G03R_BLY02A08 for Aquatic Life: Could not find data, please provide.
15. VAP-G06R_BEV01A00 for Aquatic Life: Could not find data, please provide.

16. VAT-G11L_LSL01G06 for Aquatic Life: Could not find data, please provide.
17. VAP-J11R_DPC02A00 for Recreation: Could not find data for the 2nd station, please provide.
18. VAP-K21R_SWT01A08 for Aquatic Life: Could not find data, please provide.
19. VAP-K22R_HSP01A00 for Aquatic Life: Data sheet lists data for one of two stations, please provide data for additional listing station.
20. VAP-K05R_HAY01A10 for Aquatic Life: Data sheet lists data for two of three stations, please provide data for additional listing station.
21. VAP-K08R_MHN01B10 for Recreation: Could not find data, please provide.
22. VAP-K08R_MHN01B10 for Aquatic Life: Could not find data, please provide.
23. VAT-K42E_BKY04A14 for Recreation: Tab "5BBKY000.99REC" of "Draft_DELIST_TRO_2016.xlsx" has this listed as "Black Creek (upper)", Please confirm this is for Back Bay.
24. VAS-O01R_XEE01A08 for Aquatic Life: 10 samples appear to be below 6.0 for pH, but no impairment is listed. Please clarify.
25. VAS-P17R_BLK01A96 for Aquatic Life: Could not find data, please provide.

James River and Elizabeth River PCB Impairments

The delisting rationales submitted by VADEQ included a spreadsheet that identified Fish Consumption impairments for the Elizabeth and James River water bodies were revised to better align with the Virginia Department of Health's (VDH) fish consumption advisories. From the spreadsheet, EPA identified two waterbodies that were on the 2014 303(d) list and removed from the 303(d) list for 2016: Unsegmented estuaries - Warwick River Tribs, and Burnetts Mill Creek - Tributary to Upper Nansemond River. Please explain how delisting these two waterbodies for PCBs better aligns with the fish consumption advisory. In addition, the remaining waterbodies identified on the PCB impairment spreadsheet were not 303(d) listed waters in 2014. Why are they included in the delisting rationale submittal?

Proposed Benthic "Nestings"

VADEQ's 2016 Water Quality Assessment Guidance Manual rules for nesting non-bacterial impairments and nesting guidance (letter to EPA dated December 22, 2011) discusses stressors of benthic impairment:

Nesting non-bacterial impairments may be appropriate if the existing TMDL(s) addresses all appropriate stressor(s) for benthic impairments or all source(s) for other non-bacterial impairments. It is not appropriate if new applicable stressor(s) or source(s) exist. (VADEQ, 2016)

TMDL staff will review existing TMDL(s) and watershed conditions to ensure that the stressor(s) (Benthic impairments) or source(s) (other Non-Bacterial impairments) are addressed and documented in the EPA approved TMDL and no new applicable stressor(s) or source(s) exist. (VADEQ, 2011)

In the 2016 IR, VADEQ does not include a discussion or demonstration of whether new stressors exist and are contributing to the biological impairment in any of the benthic nesting candidate rationales. In addition, VADEQ is proposing to nest tributary segments within existing TMDLs that were developed on a watershed level to address mainstem impairments, and the stressor analyses are based on mainstem monitoring data, some of which are decades old. Based on the information provided, EPA cannot determine whether the proposed nesting of the tributaries is appropriate. Please provide rationales for the proposed nesting of non-bacterial impairments that determine whether or not the biological community is impacted by the same stressor(s) as in the original TMDL, or if there are new stressors that require additional TMDL development on these tributaries.

EPA understands VADEQ is engaged in Phase II TMDL development for watersheds in Southwest Virginia, including the Levisa Fork, Powell River, Bull Creek, and Pound River watersheds. For the impaired tributaries proposed for nesting within these watersheds, EPA encourages including these benthic nesting candidates through the Phase II TMDL development process to determine if the aquatic life community is being impacted by the same stressor(s).

DEQ Response to EPA Region III

TMDL Priority List

Language has been added to Chapter 7.2 under the “Prioritization” section (page 202) to explain the meaning of the H, M, and L priority rankings in the 303(d) list. Additionally, the priority column has been changed from “TMDL Revision Priority” to “TMDL Development Priority.” Since priority waters marked with an “H” denote formal WQ-27 priorities and priority waters marked with an “M” denote internal DEQ priorities, all priority waters that DEQ plans to begin TMDL development on within the next 2 years also include a “2yr” in the “TMDL Development Priority” column. Footnotes to describe the meaning of “2yr” in addition to the H, M, and L priority rankings have been added to the 303(d) list.

Shenandoah River Algae

As noted in Chapter 4.3, during the public comment periods for the 2012 and 2014 IRs, DEQ received comments from citizens regarding the presence of algae in the Shenandoah River and concern that the algae in the river impaired the recreation designated use. Based on a thorough review of the information provided by citizen groups, DEQ determined that there was uncertainty about the attainment status of the recreation designated use for 7 assessment units (5 stream segments) in the Shenandoah River basin. As a result, 7 assessment units were classified as Category 3C for the recreational use in the 2014 IR and again in the 2016 IR. These segments were prioritized for follow-up monitoring in 2016 and 2017 by DEQ to develop and test field methods for estimating the percent coverage of river bottom by filamentous algae that are scientifically based, defensible and reproducible.

DEQ and EPA agreed to monitoring and assessment commitments to resolve the issue of impairment in the Category 3C segments in the 2018 IR. DEQ has made timely and thorough progress toward these commitments, and maintains our commitment to EPA regarding the development of tools to address water quality impacts due to excess algal growth in the Shenandoah River. Per the April 8, 2016 commitment letter between DEQ and EPA regarding Shenandoah Algae issues, DEQ has made progress toward the development of field estimation methods by conducting extensive (weekly, conditions permitting) monitoring of the 7 Category 3C Assessment Units during the 2016 and 2017 growing seasons. Much of the 2016 and 2017 monitoring seasons showed periods with minimal or no measurable algal growth. DEQ plans to evaluate all data collected (through October 2017) to develop defensible, verifiable threshold values for recreational use assessment.

DEQ held a webinar in December 2016 to present the findings of the 2016 field season interested stakeholders and members of the public. Presentations and technique demonstrations were also given at the 2017 Environment Virginia Conference held in Lexington, VA and the 2017 Mid-

Atlantic Biologists Meeting held in Cacapon, WV. The agency is currently working toward the development of impairment thresholds, which will be presented to the public in a second webinar at the conclusion of 2017 field season. The impairment thresholds will undergo formal public comment in the 2018 Integrated Report Guidance Manual.

DEQ has maintained a long-standing policy of basing impairment decisions solely on data collected with an agency-approved quality assurance plan (Level III data). It is the agency's position that third party data (photographs, Level I or II Citizen Data) will continue to be used to inform and prioritize agency monitoring efforts. The agency has engaged local citizen water monitoring groups to solicit input and feedback on the proposed field monitoring methods and to determine the role the citizen monitoring groups may play in the long-term monitoring strategy. Two meetings were held (August and September 2017) and the collaborative process with citizen monitoring groups is ongoing. Public opinion surveys may be considered as an option for future refinement of the to-be-determined impairment thresholds.

DEQ continues to advocate for a collaborative effort among the Mid-Atlantic jurisdictions that comprise EPA Region III (PA, WV, MD, VA, DEQ and DC) to develop a consistent strategy for discerning the causes of nuisance algae blooms and quantifying designated use impacts in a defensible manner.

General 303(d) List Comments & Comments on Delisting Materials

Comments are addressed in tabular format to follow. Revised benthic nesting rationales are included for additional EPA review.

303d Mileage Discrepancies

Cause Group Code(s)	2016 Listing	2014 Listing	DEQ Regional Response
A05R-02-BEN	4.76	6.19	The 2016 cause group code has been updated to include all 6.19 miles included in 2014.
A15L-01-HG	73.93	74.07	Based on updated GIS information the size has been corrected.
A15L-01-PCB			
B31L-01-PH	10.84	11.44	Based on updated GIS information the size has been corrected
G01E-03-PCB	183.259	192.222	The Fish Consumption impairments for the Elizabeth and James River water bodies were revised to better align with the Virginia Department of Health's (VDH) fish consumption advisories. These are geometry revisions performed after GIS data was merged statewide based on statewide NHD and most recent imagery reconsiliation.
G12L-02-DO	489.49	489.61	These are geometry revisions performed after GIS data was merged statewide based on statewide NHD and most recent imagery reconsiliation.
G12L-02-TP			
G14L-03-DO	715.37	715.52	These are geometry revisions performed after GIS data was merged statewide based on statewide NHD and most recent imagery reconsiliation.
I16R-01-PH	4.85	5.16	Based on updated GIS information the size has been corrected
L60R-01-HG	1655.18	1655.41	Based on updated GIS information the size has been corrected
L60R-01-PCB			
M02L-01-DDD	42.46	42.69	The lake shoreline was revised to reflect the actual footprint of the waterbody.
M02L-01-DDE			
M02L-01-DDT			
M02L-01-HG			
K23R-05-BAC	27.71	28.02	Clarification needed. Va 303d and ADB has 28.02 listed.
K28R-05-BAC	4.22	4.62	These are geometry revisions performed after GIS data was merged statewide based on statewide NHD and most recent imagery reconsiliation.
K28R-05-DO			
K32R-13-HG	36.91	37.02	The Fish Consumption impairments for the Blackwater River water bodies were revised to better align with the Virginia Department of Health's (VDH) fish consumption advisories.
	26.81	26.91	
	701.67	701.82	
	611.63	611.81	
Q09R-01-BAC	8.87	9.29	VAS-Q09R_RSS02A00 is 8.87 because a stream segment immediately downstream of the Hollow Poplar Branch confluence was removed; it had been mistakenly included. The impairment description has stayed consistent.

C01E-17-PCB	1825.564	1825.733	These are geometry revisions performed after GIS data was merged statewide based on statewide NHD and most recent imagery reconsiliation.
C07E-33-EBEN	0.248	0.364	These are geometry revisions performed after GIS data was merged statewide based on statewide NHD and most recent imagery reconsiliation.
F07L-01-PCB	7468.77	7469.59	Based on updated GIS information the size has been corrected.
N06R-03-BAC	5.38	7.48	VAS-N06R_NEW01A00 is 5.38 because an adjustment was made to align with Water Quality Standards, PWS designation.
O10R-01-PCB	<p>On the 2014 303(d) list, there is a North Fork Holston River Fish Consumption - PCB in fish tissue impairment for 13.44 miles first listed in 2010. On the 2016 303(d) list, it appears the 13.44 mile impaired segment was split and now shows two impaired segments: 4.92 miles, first listed in 1996, and 8.52 miles, first listed in 2010. Please explain.</p>		Both segments should be entered as first listed in 1996.

Missing Impairments

Cause Group Code	2014 303(d) List	DEQ Regional Response
G01E-03-PCB	0.003 sq. miles first listed in 2010, PCBs	These are geometry revisions performed after GIS data was merged statewide based on statewide NHD and most recent imagery reconsiliation.
Q12R-04-BAC	3.82 miles first listed in 2012, E. coli	Was moved to Q09R-01-BAC with bacteria impaired Russell Fork AUs.
C07E-04-BAC2	0.121 sq. miles first listed in 2010, Enterococcus	The impairment is now located within Cause Group Code C07E-04-BAC since the AUs VAT-C07E-POQ01A06 and VAT-C07E_POQ01B08 are now merged in the 2016 IR.
N37R-02-DO	8.30 miles first listed in 2010, Dissolved Oxygen	Not delisted, Category change to 5C. Immediately upstream is a wetland created by beaver ponds; impairment is the result of natural conditions.

Delisting Comments

Cause Group Code	EPA Comment	DEQ Regional Response
I30R-02-BAC	<p>This 303(d) ID was listed on the 2014 303(d) List as “Mill Creek” based off an assessment of fecal coliform (2.08 miles) in 2006 and Escherichia coli (2.08 miles) in 2008. In 2016, this Cause Group Code was listed as “Hamilton Branch” based off one assessment of Escherichia coli (6.28 miles) in 2016. Based on the Delist data, Mill Creek should be removed from the 303(d) List. Why was Hamilton Branch added with the same Cause Group Code? Please clarify.</p>	<p>The impairment on Hamilton Branch was incorrectly given the cause group code for Mill Creek. Mill Creek is a delist for the 2016 cycle. Hamilton Branch is located in the same watershed and is a new listing for the 2016 cycle. The new corrected Cause Group Code will be I30R-03-BAC. Corrections will be made to the Fact Sheet database and ADB.</p>

Proposed 4C Waterbodies

Water Name	EPA Comment	DEQ Regional Response
Stonehouse Creek Reservoir	Surrounding land-use is agriculture (hay/pasture) and adjacent stream segments are impaired by E. coli. These characteristics do not suggest the impairment is not caused by a pollutant (category 4C).	DEQ will revert back to Category 5 for these lakes until further evidence of a non-impairment becomes available.
Cherrystone Reservoir	Surrounding land-use is agriculture (hay/pasture) and adjacent stream segments are impaired by E. coli. These characteristics do not suggest the impairment is not caused by a pollutant (category 4C).	
Roaring Fork Reservoir	Surrounding land-use is agriculture (hay/pasture) and adjacent stream segments are impaired by E. coli. The waterbody is also impaired for pH with unknown sources. These characteristics do not suggest the impairment is not caused by a pollutant (category 4C).	

Kingsland Creek	<p>As stated in the natural conditions report, the surrounding land-use in the Kingsland Creek watershed is predominantly urban. VADEQ's natural condition assessment methodology calls for determination of anthropogenic impacts and highlights that land use analysis is a valuable tool for identifying potential human impacts. Although the report noted that forested buffers protect the creek from urban influence, the additional impairment of E. coli could suggest otherwise. In addition, EPA reminds VADEQ that the USGS 1999 background nutrient values used to support natural conditions assessments were updated by USGS in 2010. If nutrients continue to be evaluated for identifying potential human impacts, the updated 2010 values could be used while VADEQ works to update its natural condition methodology. Additionally, the methodology states that the impacts of acid rain should be considered for low pH waters. Was acid rain considered? The natural conditions report identifies that there is one active permitted point source discharger in the Kingsland Creek watershed. EPA notes that Chesterfield County holds a Phase I MS4 permit and lists Kingsland Creek as a waterbody receiving stormwater discharges. This is not included or discussed in the natural conditions report. Based on reasons mentioned above, more information is needed to conclude whether or not anthropogenic sources are causing impairment, and Kingsland Creek should remain in category 5.</p>	<p>Although DEQ asserts that Kingsland Creek should be reclassified as a Class VII swampwater in order to more accurately determine the correct WQS for the stream, we will retract the Swampwater Determination Report until the new methodology has been completed.</p>
Airfield Pond	<p>EPA understands that Airfield Pond will be re-listed in Category 5 for Dissolved Oxygen on the final 2016 303(d) list. Please confirm.</p>	<p>Yes, Airfield Pond will be revised to a Class III water and therefore will be listed for DO and pH impairments. However, all riverine segments feeding the pond are Class VII.</p>

4B-5E Delistings

Facility ID	EPA Comment	DEQ Regional Response
VA0088102	It appears that no monitoring data was provided for total recoverable zinc. Please clarify.	Because zinc results were not meeting the limitation during the compliance schedule, the facility installed chemical addition for zinc adsorption. The compliance schedule was eliminated in the 2015 permit, and zinc is included in the permit as a monitored only parameter. To be submitted annually. I have resubmitted 2 annual DMRs
VA0088463	DMR lists the maximum pH limit as 9.0; whereas, the limit should be 8.0, correct?	Yes It should be 8.0, they were using an older DMR with interim limit listed.
VA0073318	Virginia's criteria for metals are based on equations that include a WER multiplier, and were previously approved for CWA purposes. To reflect the latest scientific knowledge on metals speciation and bioavailability, EPA updated its national recommended aquatic life criteria for copper to include a new means of quantifying copper toxicity and to utilize a more advanced modeling approach for developing water quality criteria. This update incorporates the use of the Biotic Ligand Model (BLM) in the criteria derivation procedures. In Virginia's recent Water Quality Standard (WQS) Triennial Review, VADEQ included a copper BLM that will apply on a case-by-case basis. And correspondingly, Virginia added the BLM option for copper criteria. EPA recommends that Virginia consider, to the extent feasible, incorporating BLM input parameters into their statewide monitoring efforts. The additional monitoring will ensure that data are available as Virginia considers the BLM in future WQS Triennial Reviews. For more information on the BLM input parameters. See https://www.epa.gov/wqc/aquatic-life-criteria-copper .	DEQ Piedmont Regional Office Permitting and Planning staff provided additional information to Cheryl Atkinson on or around 8/24/17.

VA0024121	<p>Virginia's criteria for metals are based on equations that include a WER multiplier, and were previously approved for CWA purposes. To reflect the latest scientific knowledge on metals speciation and bioavailability, EPA updated its national recommended aquatic life criteria for copper to include a new means of quantifying copper toxicity and to utilize a more advanced modeling approach for developing water quality criteria. This update incorporates the use of the Biotic Ligand Model (BLM) in the criteria derivation procedures. In Virginia's recent Water Quality Standard (WQS) Triennial Review, VADEQ included a copper BLM that will apply on a case-by-case basis. And correspondingly, Virginia added the BLM option for copper criteria. EPA recommends that Virginia consider, to the extent feasible, incorporating BLM input parameters into their statewide monitoring efforts. The additional monitoring will ensure that data are available as Virginia considers the BLM in future WQS Triennial Reviews. For more information on the BLM input parameters. See https://www.epa.gov/wqc/aquatic-life-criteria-copper.</p>	DEQ Piedmont Regional Office Permitting and Planning staff provided additional information to Cheryl Atkinson on or around 8/24/17.
VA0062880	<p>Virginia's criteria for metals are based on equations that include a WER multiplier, and were previously approved for CWA purposes. To reflect the latest scientific knowledge on metals speciation and bioavailability, EPA updated its national recommended aquatic life criteria for copper to include a new means of quantifying copper toxicity and to utilize a more advanced modeling approach for developing water quality criteria. This update incorporates the use of the Biotic Ligand Model (BLM) in the criteria derivation procedures. In Virginia's recent Water Quality Standard (WQS) Triennial Review, VADEQ included a copper BLM that will apply on a case-by-case basis. And correspondingly, Virginia added the BLM option for copper criteria. EPA recommends that Virginia consider, to the extent feasible, incorporating BLM input parameters into their statewide monitoring efforts. The additional monitoring will ensure that data are available as Virginia considers the BLM in future WQS Triennial Reviews. For more information on the BLM input parameters. See https://www.epa.gov/wqc/aquatic-life-criteria-copper.</p>	DEQ Piedmont Regional Office Permitting and Planning staff provided additional information to Cheryl Atkinson on or around 8/24/17.
VA0003867	<p>EPA is concerned that the increased number of seagulls surrounding the facility is likely due to the presence of the discharger's facility processes/operations. Measures to reduce the presence of seagulls and their negative impacts on water quality near the facility should be taken.</p>	I have passed on this information to the Permit Writer

VA0005215	Permit lists “total residual chlorine” instead of “total recoverable chlorine”. Please explain.	For saltwater, the Water Quality Standard for chlorine is Chlorine Produced Oxidant (ug/L). This is measured by Total Residual Chlorine. Total Recoverable Chlorine is not a parameter.
VA0089982	Why is it appropriate to remove the total recoverable limits for zinc and copper even though monitoring data shows non-compliance? Although monitoring for dissolved metals and WET testing will occur, a limit may still necessary to maintain water quality. Please explain.	The permit writer determined that they were meeting these limits since they were removed from their new permit that was issued in 2014.

Waterbody Delistings

ID305b	EPA Comment	DEQ Regional Response
VAV-B40R_GRS01A10	Aquatic Life: The VRO Delist package lists the stream size as 3.46 miles; whereas 3.64 is listed on the master spreadsheet. Please clarify.	The mileage number in the de-listing memo is transposed. The correct mileage is 3.64.
VAV-B56R_CRO01A00	Aquatic Life: What is the river mile location of the original listing station 1BCRO-CRO1-FOSR?	This station is measured at river mile 9.17
VAV-B57R_RSC01A00	Aquatic Life: Table in VRO Delist package lists this as a partial delisting. Is this correct? If so, what is the remaining impairment size/pollutant?	The remaining impairment is bacteria and is included in with Page Brook Run and Spout Run. The total impairment size is 6.39 miles for Roseville Run, 15.10 for Page Brook/Spout Run.
VAP-A32R_NOM02A14	Aquatic Life: Could not find data, please provide.	The delist package has been revised to include the applicable data (A32R-06-PH)
VAN-E14R_ROB01A06	Recreation: Could not find data, please provide.	This delisting actually occurred in 2012IR; the delisting comment was inadvertently not removed from ADB for 2014 and 2016 assessments.
VAP-E26E_MEA03A10	Recreation: Please explain why DO was used to judge attainment with recreation designated use.	The Recreation Use was not delisted - it has been assessed as fully supporting since the 2014 cycle based on data collected in 2012 at station 3-MEA000.77. The delisting for the Aquatic Life Use was based on dissolved oxygen in
VAP-F13R_TPT01A98	Aquatic Life: Data sheet only lists data for one of six listed monitoring stations, please provide data for additional monitoring stations.	The delist package has been revised to include the requested data (F13R-02-PH)
VAT-C07E_NWB01B08	Shellfishing: Could not find data, please provide.	The shellfish delist language will be removed from ADB.

VAT-C07E_WHH01A06	Recreation: Third party collected data to demonstrate high E. coli, but because the WQS is based on Enterococci, VA is delisting the segment as “insufficient data”. Water quality data should be used to determine a waterbody is no longer impaired. EPA suggests the segment remain on Category 5 until Enterococci data are collected and evaluated.	The impairment was listed in error based on third party data that was Level II data (not able to be used to make an assesment impairment or support designation). The data also was Ecoli which is not the applicable water quality standard in Class II waters.
VAT-D03R_GAR01A02	Aquatic Life: Please explain the seasonal effects impacting spring IBI scores. The average IBI score is 39.6, which is below the threshold of 40. Additionally, please explain why IBI scores are averaged. VADEQ’s assessment guidance (page 25) notes that averaging IBI scores would “weaken the ability to accurately predict current conditions”.	Benthic scores in mid-Atlantic coastal plain waters yield results in the lower 10th percentile in the spring. This stream consistently scores well above the 25 th percentile for the VCPMI in the fall and exhibits healthy supportive conditions for a diverse benthic community. Based on the biologist’s best professional judgment along with high fall scores and the most recent two-year average score of 39.6, DEQ feels that Gargathy Creek has a healthy benthic community and therefore a delist is appropriate for the aquatic life use in the 2016 IR. In addition to the benthic assessment, an evaluation of the habitat and lack of anthropogenic inputs to the stream would further support this water as a candidate for a delist.
VAC-H35R_LWW01A08	Aquatic Life: The data sheets show E. coli data, but the spreadsheet lists DO as the parameter. Please clarify.	The heading for the second set of data from the 2016 assessment period has been corrected. The delist mistakenly referred to the data as <i>E. coli</i> data and in support of the <i>recreational</i> use support. The data that were presented are dissolved oxygen data from the 2016 assessment period. The segment now meets the minimum dissolved oxygen standard and aquatic life use with a 2 out of 23 (8.7%) violation rate. The segment remains impaired for E. coli.
VAP-H34R_RSM01A08	Aquatic Life: Could not find data, please provide.	Was submitted to EPA - page 49 of "2016 PRO Delist Package - SF and benthic fact sheets_JVP.pdf"

VAP-H39R_XUT01A04	Aquatic Life: Could not find data, please provide.	The delist package has been revised to include the applicable data (H39R-02-DO)
VAP-G03R_BLY02A08	Aquatic Life: Could not find data, please provide.	Was submitted to EPA - in the delist package under G03R-02-DO.
VAP-G06R_BEV01A00	Aquatic Life: Could not find data, please provide.	The delist package has been revised to include the applicable data (G06R-06-PH Partial)
VAT-G11L_LSL01G06	Aquatic Life: Could not find data, please provide.	The delist package for Lake G will be added for DO delist statement for Lone Star Lake G.
VAP-J11R_DPC02A00	Recreation: Could not find data for the 2nd station, please provide.	The delist package has been revised to include the applicable data (J11R-02-BAC)
VAP-K21R_SWT01A08	Aquatic Life: Could not find data, please provide.	DO violations were documented in this water in 2008. It has since been formally re-classified as a swamp water (Class VII). Per Virginia's Water Quality Standards (9VAC25-260-50), numeric dissolved oxygen standards only apply to Class VII waters when there is sufficient evidence the narrative criterion is not protective of aquatic life uses. To date, this Class VII water has not exhibited a need for a site-specific DO criterion, so the DO impairment has been removed
VAP-K22R_HSP01A00	Aquatic Life: Data sheet lists data for one of two stations, please provide data for additional listing station.	The delist package has been revised to include the applicable data (K22R-02-DO)
VAP-K05R_HAY01A10	Aquatic Life: Data sheet lists data for two of three stations, please provide data for additional listing station.	The delist package has been revised to include the applicable data (K05R-05-PH)
VAP-K08R_MHN01B10	Recreation: Could not find data, please provide.	The delist package has been revised to include the applicable data (K08R-01-BAC)

VAP-K08R_MHN01B10	Aquatic Life: Could not find data, please provide.	The delist package has been revised to include the applicable data (K08R-01-PH)
VAT-K42E_BKY04A14	Recreation: Tab "5BBKY000.99REC" of "Draft_DELIST_TRO_2016.xlsx" has this listed as "Black Creek (upper)". Please confirm this is for Back Bay.	Confirmed the waterbody to be delisted is the Back Bay segment. The delist package will be revised.
VAS-O01R_XEE01A08	Aquatic Life: 10 samples appear to be below 6.0 for pH, but no impairment is listed. Please clarify.	Error was corrected, not a delist.
VAS-P17R_BLK01A96	Could not find data, please provide.	Error was corrected, not a delist.

James River & Elizabeth River PCBs

EPA Comment	DEQ Regional Response
<p>The delisting rationales submitted by VADEQ included a spreadsheet that identified Fish Consumption impairments for the Elizabeth and James River water bodies were revised to better align with the Virginia Department of Health's (VDH) fish consumption advisories. From the spreadsheet, EPA identified two waterbodies that were on the 2014 303(d) list and removed from the 303(d) list for 2016: Unsegmented estuaries - Warwick River Tribs, and Burnetts Mill Creek - Tributary to Upper Nansemond River. Please explain how delisting these two waterbodies for PCBs better aligns with the fish consumption advisory.</p>	<p>TRO delisted the Unsegmented estuaries - Warwick River Tribs and Burnetts Mill Creek - Tributary to Upper Nansemond River to align with the VDH Fish Consumption advisory which does not include the Warwick River or Burnetts Mill Creek or their tributaries as included in the James River PCB impairment as stated below from the Jame River Advisory: James River (from the I-95 James River bridge in Richmond downstream to the Hampton Roads Bridge Tunnel and the tidal portion of the following tributaries: Appomattox River up to Lake Chesdin Dam, Bailey Creek up to Rt. 630, Poythress Run, Bailey Bay, Chickahominy River up to Walkers Dam, Skiffes Creek up to Skiffes Creek Dam, Pagan River and its tributary Jones Creek, Chuckatuck Creek, Nansemond River and its tributaries Bennett Creek and Star Creek, Hampton River, Willoughby Bay and the Elizabeth River system (Western Br., Eastern Br., Southern Br., and Lafayette River) and tidal tributaries St. Julian Creek, Deep Creek, and Broad Creek. These river segments comprise ~325 miles).</p>
<p>In addition, the remaining waterbodies identified on the PCB impairment spreadsheet were not 303(d) listed waters in 2014. Why are they included in the delisting rationale submittal?</p>	<p>All segments delisted for PCBs in 2016 IR were listed as impaired in the 2014 IR as impaired under the Cause Group Code G01E-03-PCB.</p>

Benthic TMDL Nesting Rationale

Cavitts Creek, Tazewell County, Virginia

Completed TMDL Name: Total Maximum Daily Load (TMDL) Development for the Upper Clinch River Watershed
Stream Name: Clinch River
TMDL Completion Date: 4/24/2004

Benthic Impaired Segments Included in the TMDL:

- 1) Assessment Unit ID: VAS-P01R_CLN01A98
TMDL ID: P01R-01-BEN, 24478
Segment Length: 6.14 miles
Segment Description: Mainstem of the Clinch River from the North Fork Clinch River confluence through the Town of Tazewell to the Plum Creek confluence

Segments for Nesting in the 2016 Integrated Assessment:

- 1) Assessment Unit ID: VAS-P01R_CAV01A00
TMDL ID: P01R-01-BEN
Segment Length: 2.4 miles
Segment Description: Lower mainstem of Cavitts Creek from Johnson Branch to the confluence with the Clinch River at River Jack

Justification for Nesting:

The Total Maximum Daily Load (TMDL) Development for the Upper Clinch River Watershed was completed in 2004 and approved by EPA in April of 2004. Figure 1 presents the Upper Clinch River TMDL watershed boundary, which includes Cavitts Creek. The approved TMDL took into account and modeled all point and non-point sources of potential benthic stressors in the watershed. The process outlined in USEPA's Stressor Identification Guidance Document (USEPA, 2000) was used to identify the critical probable stressor(s) for the Upper Clinch River. Analysis of physical, chemical, biological, and observational data indicated that sediment was the most probable cause of the benthic impairment. Point sources discharging sediment were identified and given wasteload allocations (WLA) based on their issued Virginia Pollution Discharge Elimination System (VPDES) permits. Table 1 from the Aquatic Life Use TMDL lists the DEQ VPDES permits in the Upper Clinch River watershed and associated WLA for each. The land uses for the approved Upper Clinch River TMDL area are comparable and consistent with the proposed nested segments. Data from the 2011 edition of the National Land Cover Database has been used to provide an updated and more accurate description of land uses in the watershed. Figure 2 presents land uses in the Upper Clinch River watershed.

Cavitts Creek was listed as impaired for aquatic life in 2016. The proposed nested segment falls within both the watershed and TMDL boundary for the Upper Clinch River. The Cavitts Creek impairment is based on data collected at a DEQ biological monitoring stations (Figure 3). Table

2 presents the DEQ Virginia Stream Condition Index data collected at the monitoring station. Table 3 summarizes the benthic metrics. Table 4 summarizes the habitat data for the monitoring stations.

Field physical parameters collected on Cavitts Creek include temperature, pH, dissolved oxygen (DO), and conductivity. Plots of field parameters are shown in figures 4-7. Where applicable, minimum and/or maximum water quality standards are indicated. Cavitts Creek is a Class IV Mountainous Zone Water.

Figure 1 – Proposed Segments for Nesting

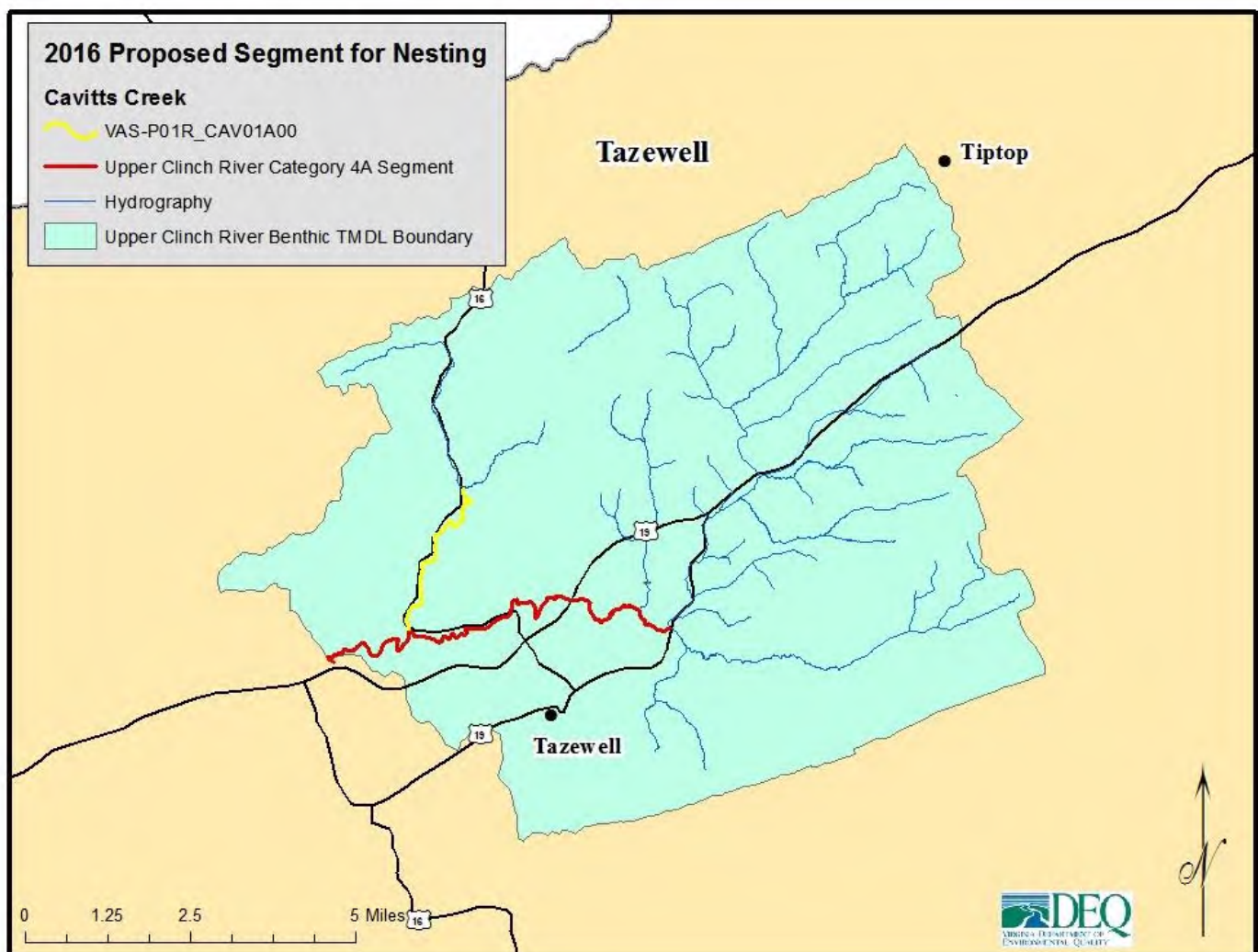


Figure 2 – Land use in the Upper Clinch River Watershed

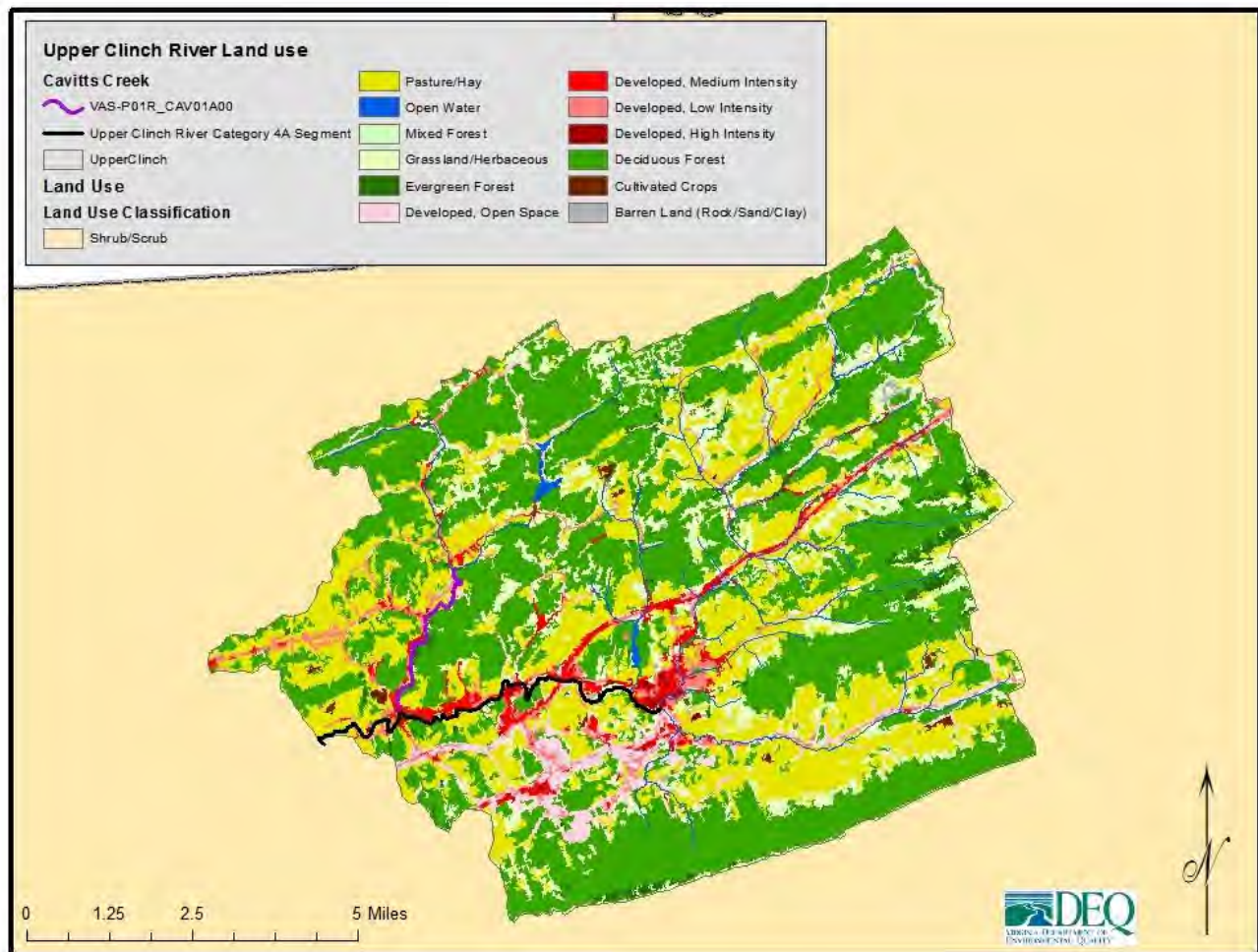


Figure 3 – Monitoring Stations for Proposed Nested Segments

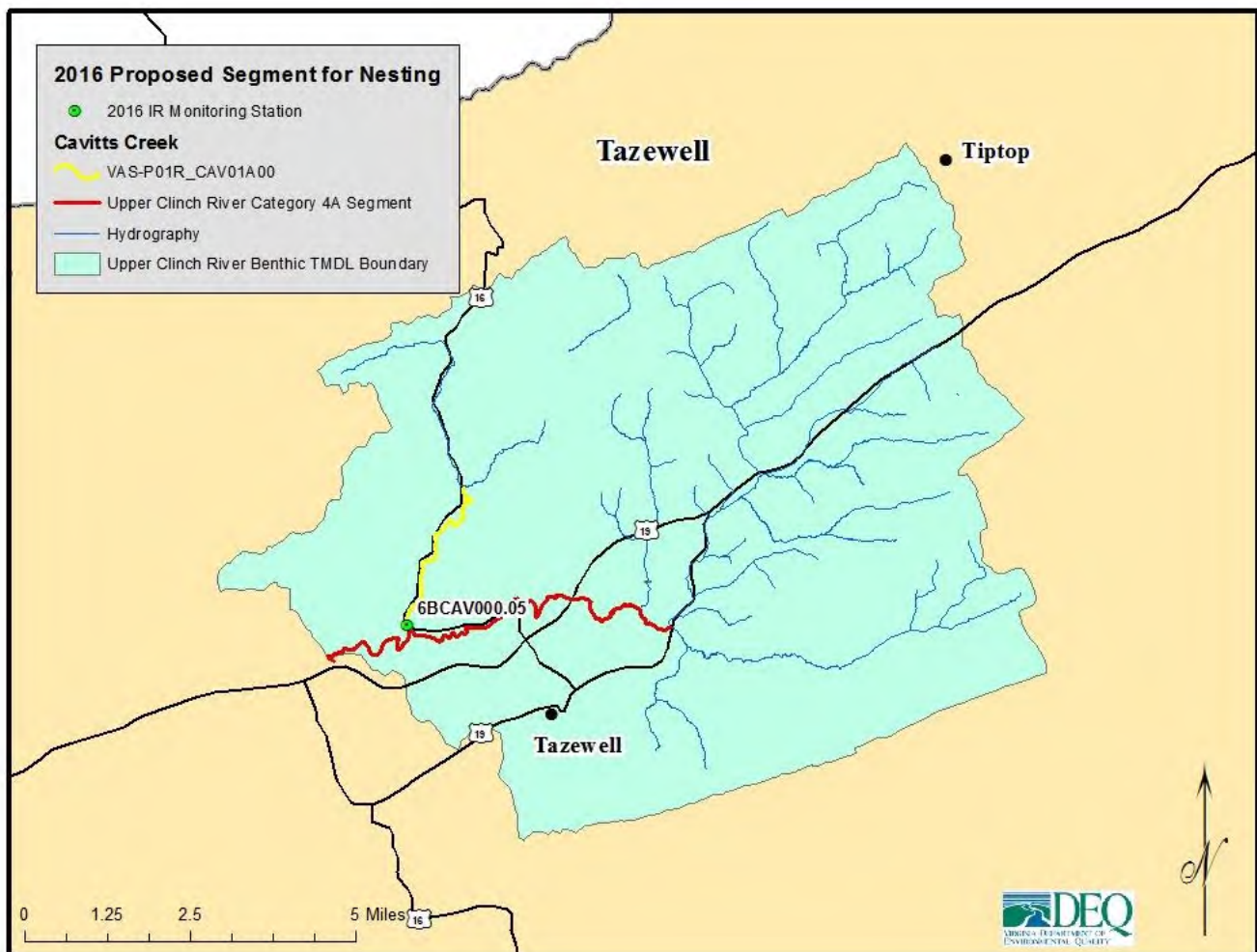


Table 1 – DEQ Permitted Discharges, from the Upper Clinch River TMDL (pg. 6-2)

TMDL (lbs/yr)	LA (lbs/yr)	WLA (lbs/yr)	MOS (lbs/yr)	Overall % Reduction
7,580,309	6,614,615	Total = 206,636	759,058	54.2%
		Glenrae Mobile Home = 866		
		Tazewell WWTP = 182,764		
		Greater Tazewell Area Reg WTP = 5,766		
		Tazewell County Landfill = 17,070		
		Bannies Wash Bays = 140		

Table 2 – Nested Segment Biological Monitoring Scores

VDEQ Station 6BCAV000.05	
Sample Date	Virginia Stream Condition Index Score (VSCI)
09/29/2008	65
06/02/2009	56
03/17/2014	48
11/10/2014	46

Table 3 – Benthic Metrics

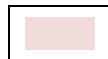
Station ID	6BCAV000.05			
Metric	09/29/2008	06/02/2009	03/17/2014	11/10/2014
Richness Score	68.18	63.64	50.00	77.27
EPT Score	54.55	54.55	36.36	45.45
% Ephem Score	80.34	33.09	26.69	4.25
% P+T-H Score	0.00	0.00	0.00	1.46
% Scraper Score	70.12	81.36	63.42	36.34
% Chironomidae Score	90.95	79.25	72.73	95.31
% 2 Dom. Score	74.80	64.07	61.74	49.67
% MFBI Score	82.32	78.87	74.20	59.95

Table 4 – Habitat Evaluation for Cavitts Creek

Habitat Metrics	Station ID	6BCAV000.05			
	Collection Date	09/29 2008	06/02 2009	03/17 2014	11/10 2014
Channel Alteration	ALTER	16	14	15	14
Bank Stability	BANKS	10	13	14	14
Bank Vegetation	BANKVEG	6	9	12	12
Embeddedness	EMBED	14	16	10	13
Channel Flow Status	FLOW	17	19	18	20
Frequency of Riffles	RIFFLES	12	14	16	10
Riparian Vegetation	RIPVEG	4	8	12	10
Sediment Deposition	SEDIMENT	11	9	10	11
Substrate Availability	SUBSTRATE	15	17	17	17
Velocity/Depth Regime	VELOCITY	10	14	12	10
10-Metric Total		115	133	136	131



Habitat metric score assessed as “suboptimal”



Habitat metric score assessed as “marginal” or “poor”

Figure 4 – Field Temperature

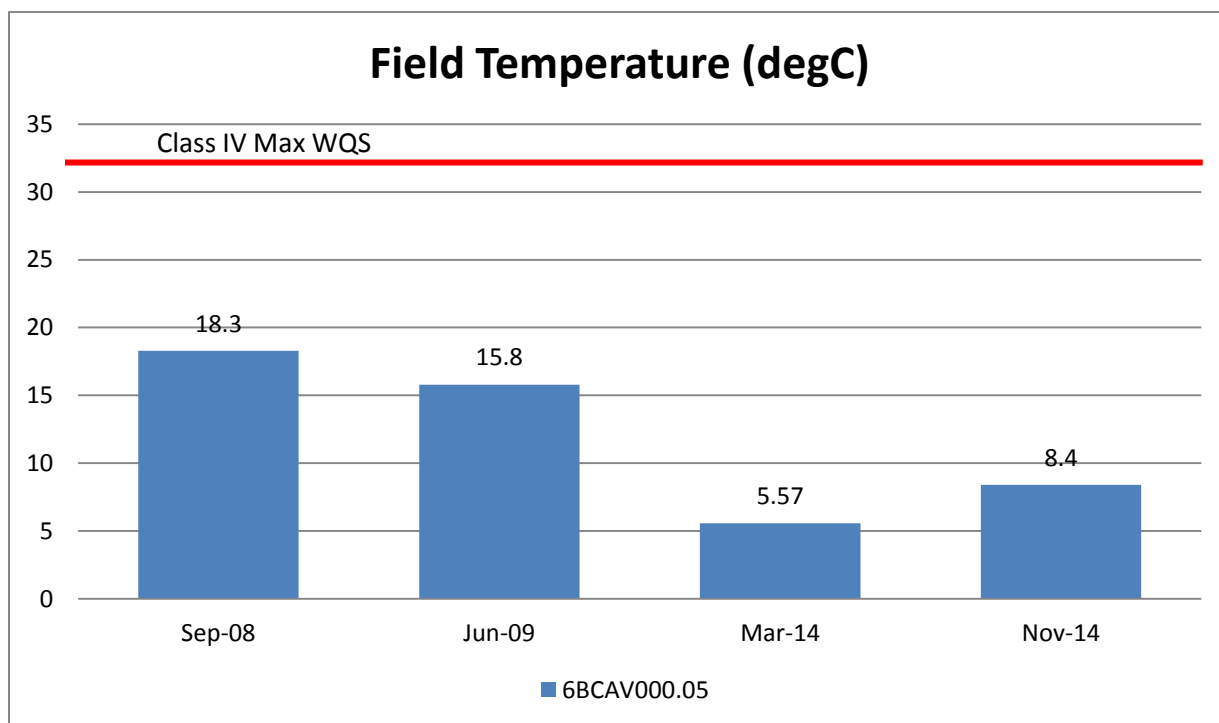


Figure 5 – Field pH

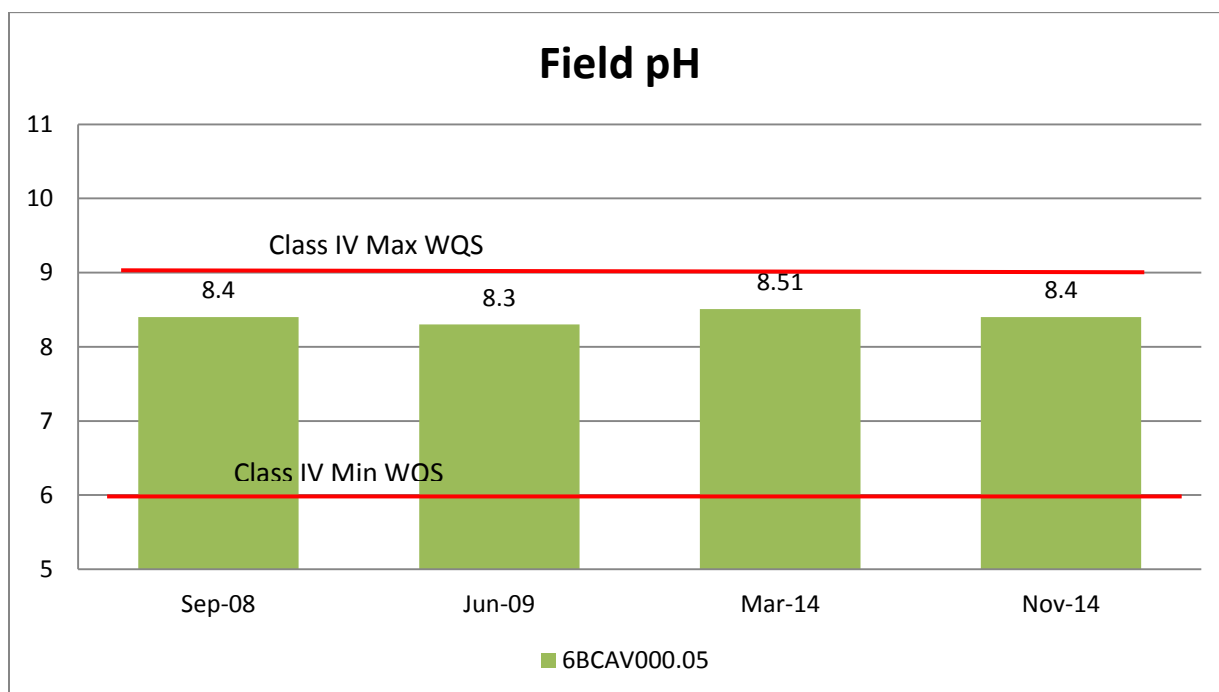


Figure 6 – Field DO

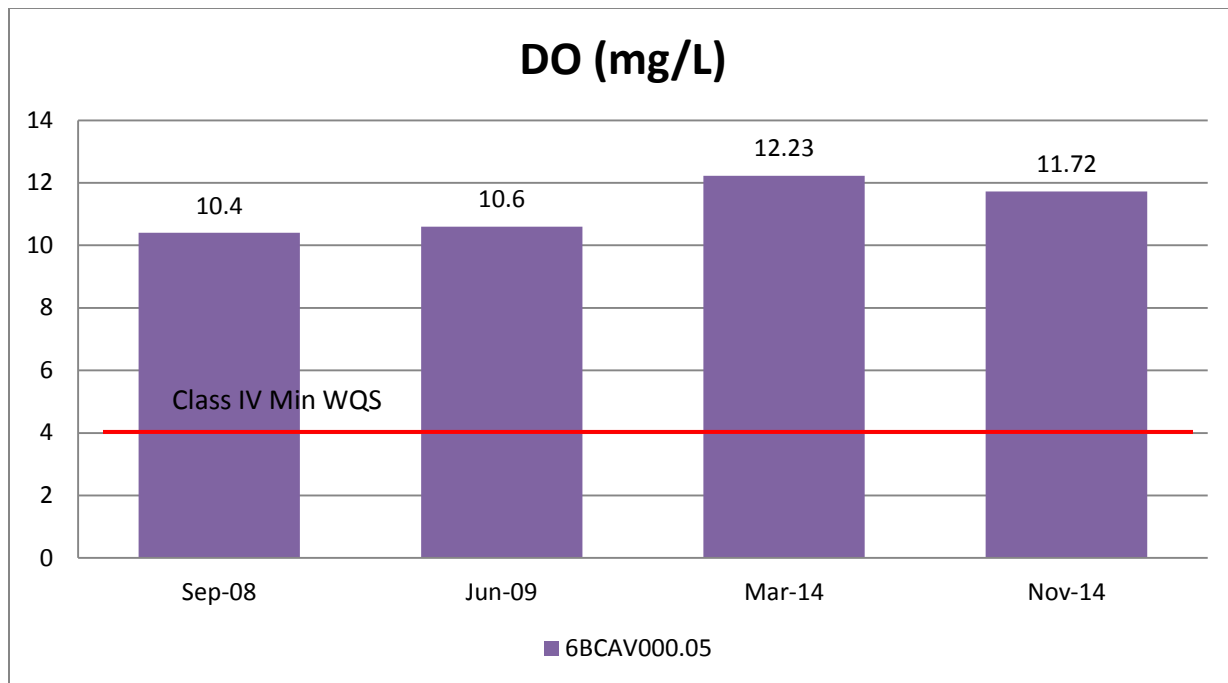
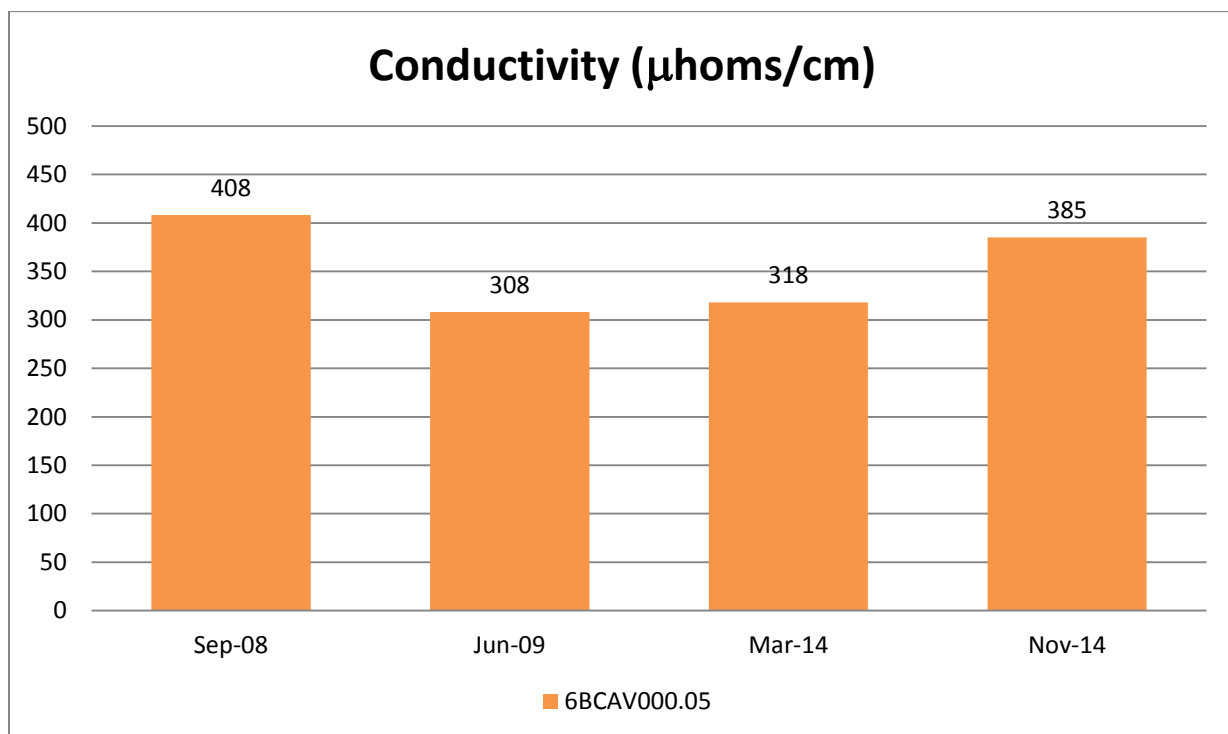


Figure 7 – Field Conductivity



Section 3 of the Benthic TMDL Development for the Upper Clinch River identifies excessive sedimentation from non-point source inputs as primarily responsible for the benthic impairment in the Upper Clinch River. A review of the available water quality data for the proposed nested segment indicates that field parameters are within expected ranges.

Sediment is supported as a probable stressor for these segments due to the suboptimal and marginal habitat metric related to sediment. Marginal bank stability along with the presence of fine sediments indicates sediment deposition. The impairment is relatively minor and sediment related habitat metrics are in the middle range, sediment seems to be the most probable cause of stress to the benthic community in Cavitts Creek.

The impairment on Cavitts Creek can be fully addressed through implementation of the Upper Clinch River TMDL.

Based on the rationale listed above, it is our recommendation that the above mentioned assessment unit be placed in Category 4A for the Aquatic Life Use.

Benthic TMDL Nesting Rationale

Chestnut Creek, City of Galax and Grayson County, Virginia

Completed TMDL Name: Total Maximum Daily Load (TMDL) Development for the Chestnut Creek Fecal Bacteria and General Standard (Benthic)
Stream Name: Chestnut Creek
TMDL Completion Date: 06/07/2006

Benthic Impaired Segments Included in the TMDL:

- 1) Assessment Unit ID: VAS-N06R_CST01A94
TMDL ID: N06R-01-BEN, 233358
Segment Length: 8.68 miles
Segment Description: Lower Chestnut Creek from the Skunk Branch confluence at Allied Gossan mine, river mile 8.06 downstream to the confluence with the New River

Segments for Nesting in the 2016 Integrated Assessment:

- 1) Assessment Unit ID: VAS-N06R_CST02A94
TMDL ID: N06R-01-BEN, 233358
Segment Length: 5.68 miles
Segment Description: Segment extends from the City of Galax Water Treatment Plant intake, river mile 14.27, downstream to the Allied-Signal Gossan mine discharge, river mile 8.06

Justification for Nesting:

The Total Maximum Daily Load (TMDL) Development for the Chestnut Creek was completed in 2006 and approved by EPA in June of 2006. Figure 1 presents the Chestnut Creek TMDL watershed boundary, which includes the proposed segment for nesting. The approved TMDL took into account and modeled all point and non-point sources of potential benthic stressors in the watershed. The process outlined in USEPA's Stressor Identification Guidance Document (USEPA, 2000) was used to identify the critical probable stressor(s) for the Chestnut Creek. Analysis of physical, chemical, biological, and observational data indicated that sediment was the most probable cause of the benthic impairment. Point sources discharging sediment were identified and given wasteload allocations (WLA) based on their issued Virginia Pollution Discharge Elimination System (VPDES) permits. Table 1 from the TMDL lists the DEQ VPDES permits in the Chestnut Creek watershed and associated WLA for each. Table 2 presents the TMDL targets for Chestnut Creek. The land uses for the approved Chestnut Creek TMDL area are comparable and consistent with the proposed nested segments. Data from the 2011 edition of the National Land Cover Database has been used to provide an updated and more accurate description of land uses in the watershed. Figure 2 presents land uses in the Chestnut Creek watershed.

Chestnut Creek was listed as impaired for aquatic life in 2004. The proposed nested segment falls within both the watershed and TMDL boundary for the Chestnut Creek. The Chestnut Creek impairment is based on data collected at a DEQ biological monitoring station (Figure 3). Table 3 presents the DEQ Virginia Streams Condition Index data collected at the monitoring station. Table 4 summarizes the benthic metrics. Table 5 summarizes the available habitat data.

Field physical parameters collected on Chestnut Creek include temperature, pH, dissolved oxygen (DO), and conductivity. Plots of field parameters are shown in Figures 4-7. Where applicable minimum and/or maximum water quality standards are indicated. Chestnut Creek is a Class IV Mountainous Zone Water.

Figure 1 – Proposed Segments for Nesting

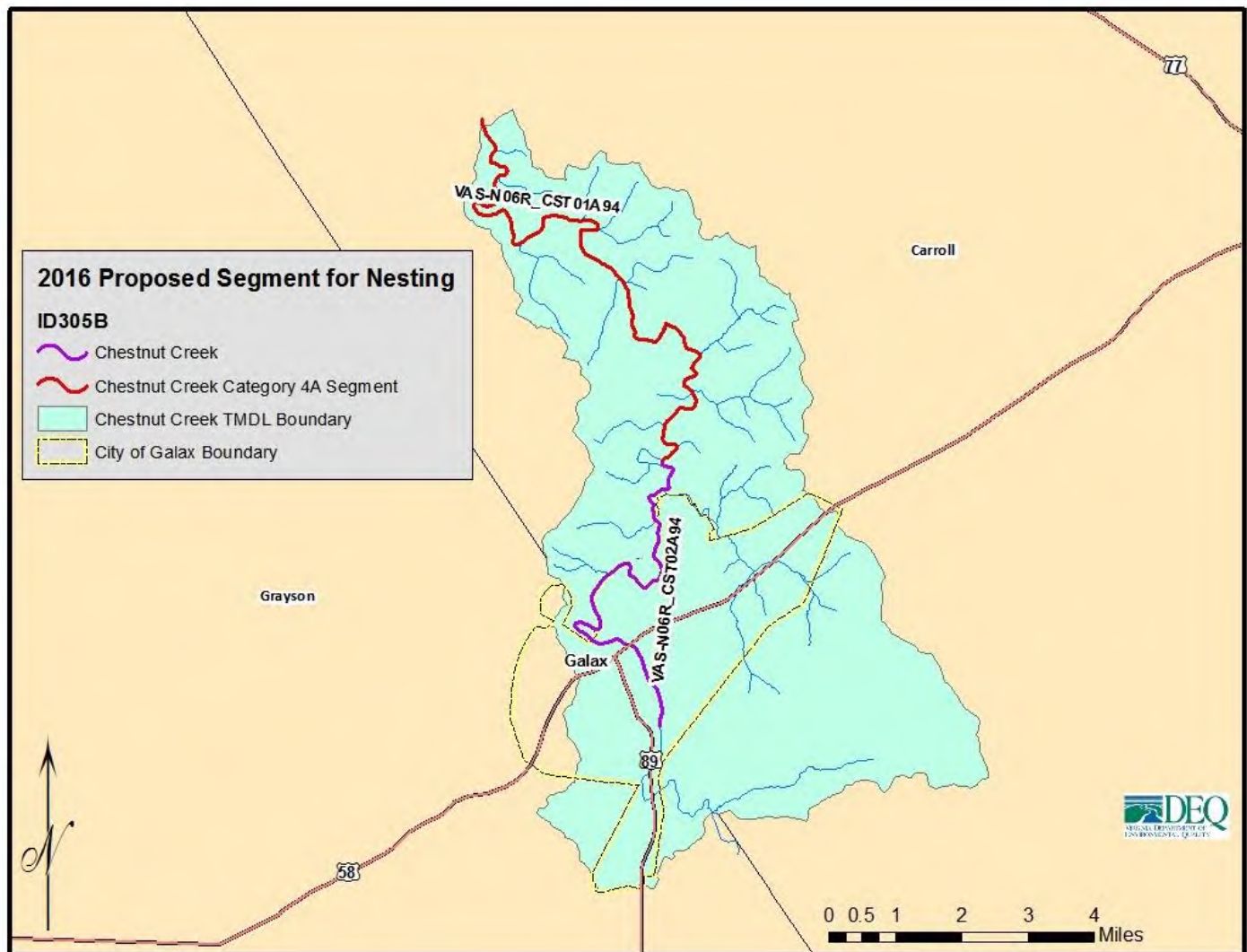


Figure 2 – Land use in the Chestnut Creek Watershed

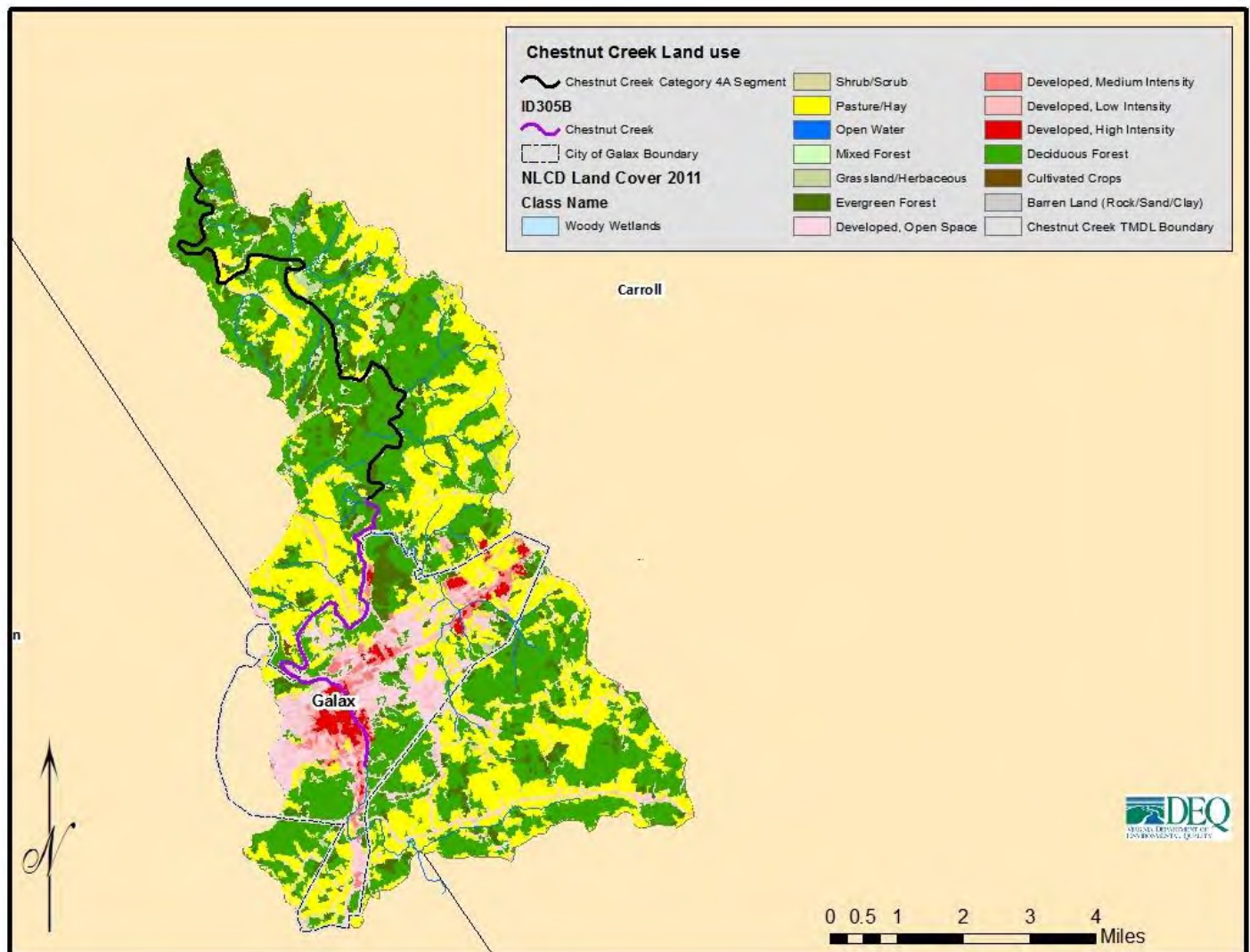


Figure 3 – Monitoring Stations for Proposed Nested Segments

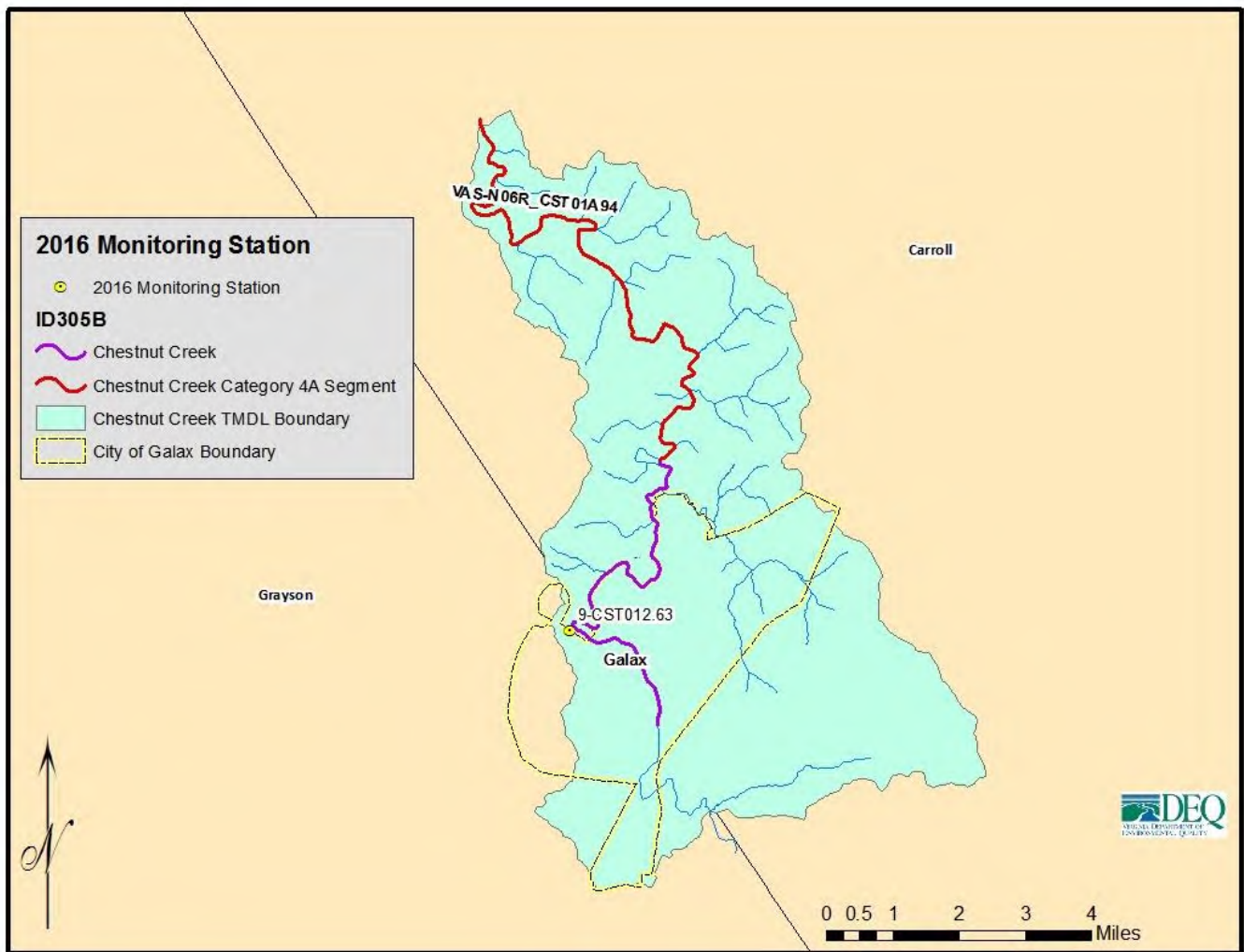


Table 1.DEQ Permitted Dischargers, from the Chestnut Creek TMDL (pg. 9-11)

Existing Conditions					Future Conditions	
Perm it Discharge	Runoff	Area	Conc.	T SS	TSS	
(MGD)	(cm/yr)	(ha)	(mg/L)	(t/yr)	(t/yr)	
VPDES Permits:						
VA0082 333	0.10		50	6.913	6.913	
Residential Sewage Treatment Permits:						
VAG400062	0.001		30	0.041	0.041	
VAG400439	0.0 01		30	0.041	0.041	
Construction Stormwater Discharge Permits:						
VAR100070	1 6.492	3 .618	100	0.597	0.597	
VAR100 556	1 6.492	2 .355	100	0.388	0.388	
Industrial Stormwater Discharge Permits:						
VAR050012	3 8.483	0 .526	100	0.202	0.202	
VAR0500 14	3 8.483	12.141	100	4.672	4.672	
VAR0 50015	38.483	1.133	100	0.436	0.436	
VAR050019	38.483	7.649	0	0	0	
VAR050049	3 8.483	7.123	100	2.741	2.741	
VAR0 50099	3 8.483	4 .128	100	1.589	1.589	
VAR050100	3 8.483	2 .550	100	0.981	0.981	
VAR050101	3 8.483	0 .769	100	0.296	0.296	
VAR051557	0	0	0	0	0	
Total				18.90	18.90	

Table 2. TMDL targets for Chestnut Creek (pg. 10-6)

Impairment	WLA (t/yr)	LA (t/yr)	MOS (t/yr)	TMDL (t/yr)
Chestnut Creek	18.9	6,597	735	7,351

Table 3 – Nested Segment Biological Monitoring Scores

VDEQ Station 9-CST012.63	
Sample Date	Virginia Stream Condition Index Score (VSCI)
04/24/2013	56
10/03/2013	50

Table 4 – Benthic Metrics

Station ID	9-CST012.63	
Metric	04/24/2013	10/03/2013
Richness Score	59.09	59.09
EPT Score	36.36	45.45
% Ephem Score	90.46	59.32
% P+T-H Score	0.00	0.00
% Scraper Score	33.47	22.90
% Chironomidae Score	80.91	77.27
% 2 Dom. Score	80.14	70.94
% MFBI Score	74.73	71.26

Table 5 – Habitat Evaluation for Chestnut Creek

Habitat Metrics	Station ID	9-CST012.63	
	Collection Date	04/24 2013	10/03 2013
Channel Alteration	ALTER	18	15
Bank Stability	BANKS	12	14
Bank Vegetation	BANKVEG	13	14
Embeddedness	EMBED	13	10
Channel Flow Status	FLOW	19	15
Frequency of Riffles	RIFFLES	8	5
Riparian Vegetation	RIPVEG	15	15
Sediment Deposition	SEDIMENT	6	3
Substrate Availability	SUBSTRATE	15	12
Velocity/Depth Regime	VELOCITY	15	15
10-Metric Total		134	118



 Habitat metric score assessed as “suboptimal”
 Habitat metric score assessed as “marginal” or “poor”

Figure 4 – Field Temperature

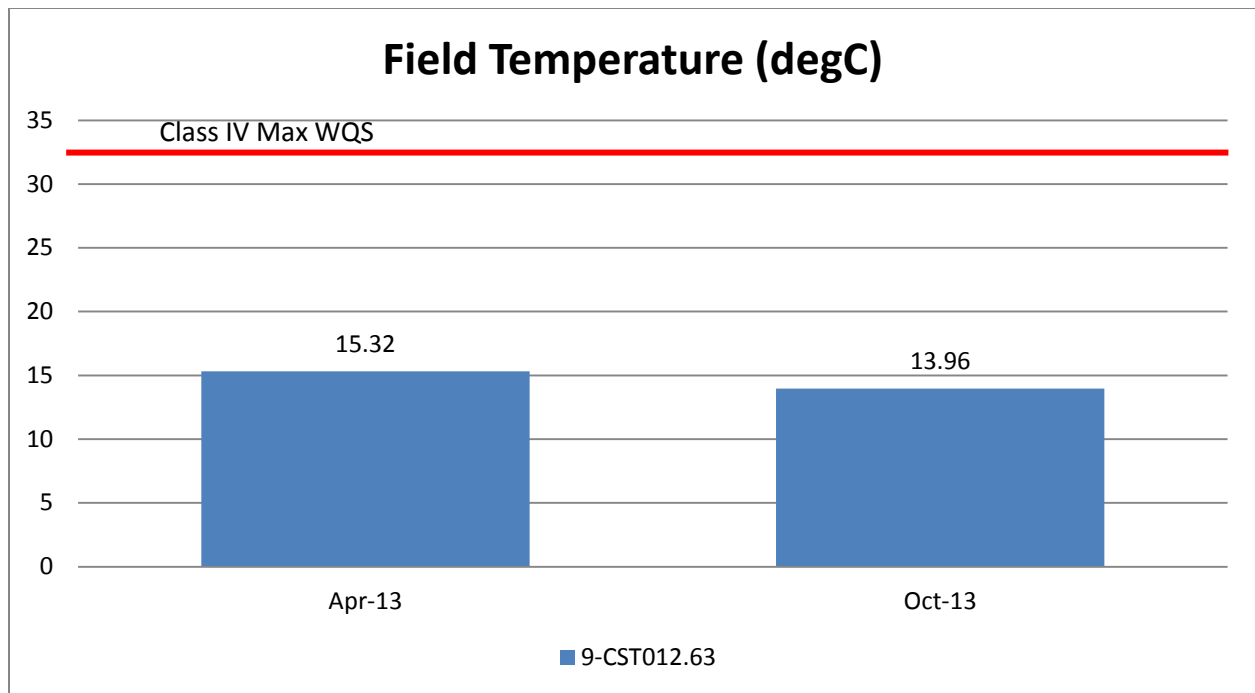


Figure 5 – Field pH

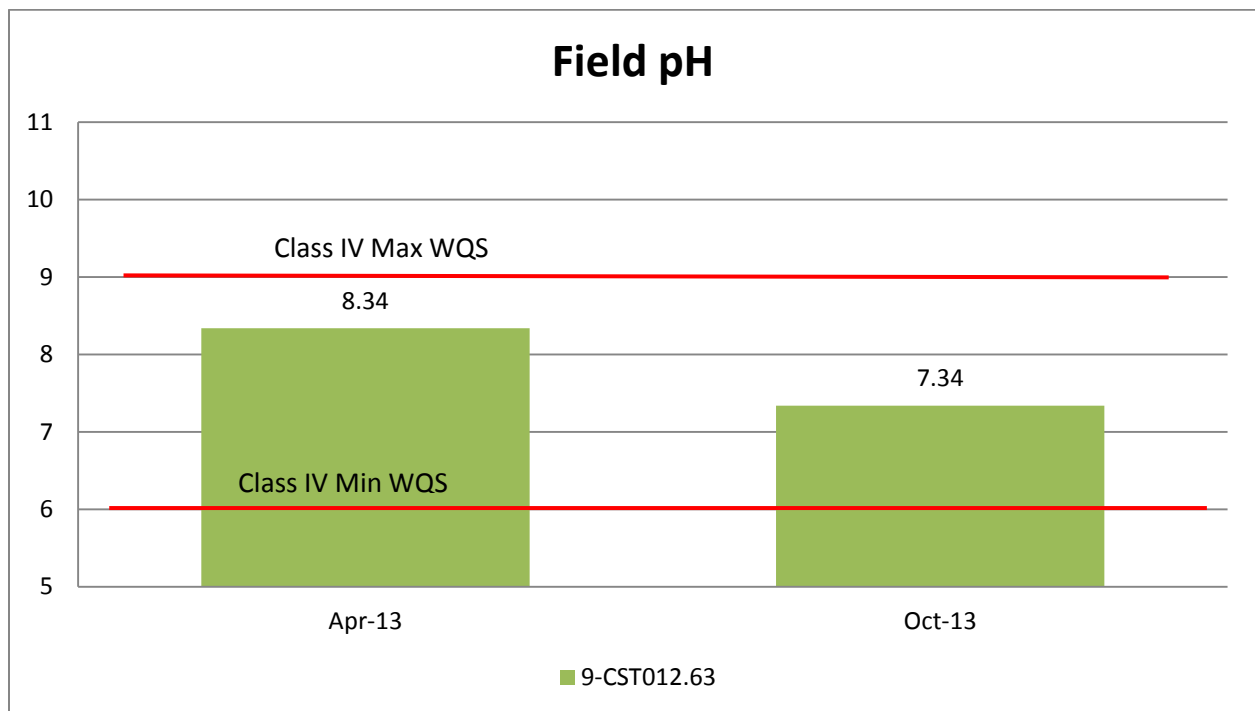


Figure 6 – Field DO

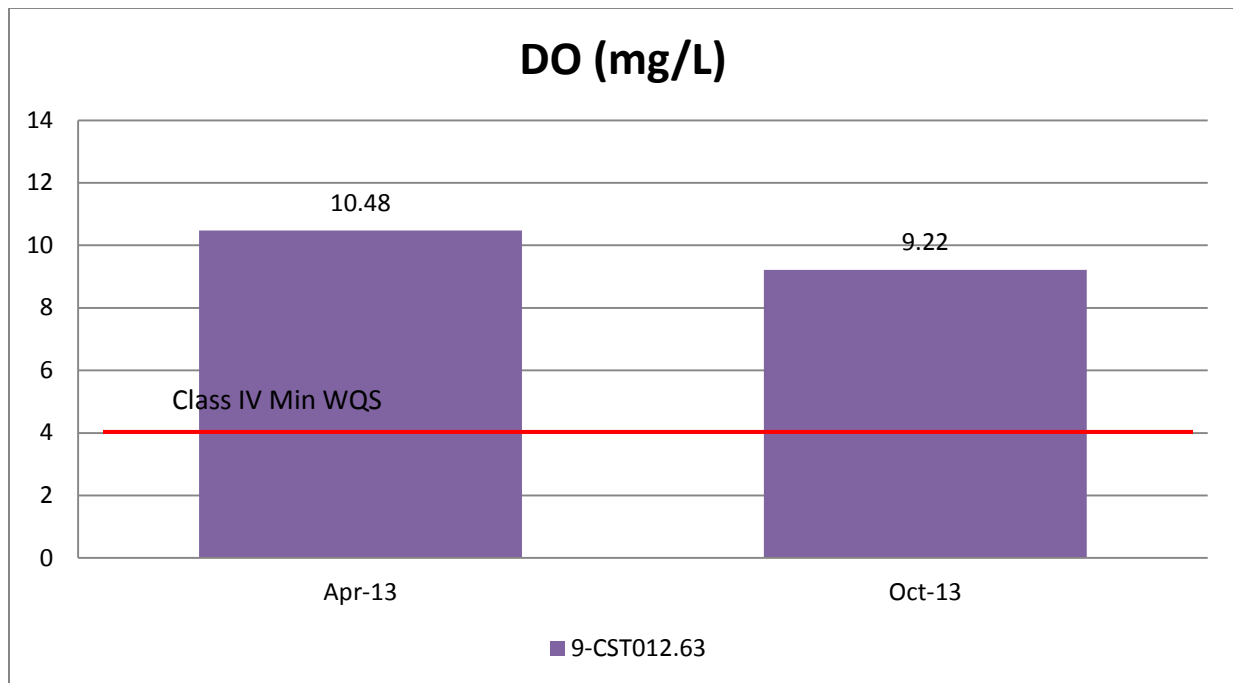
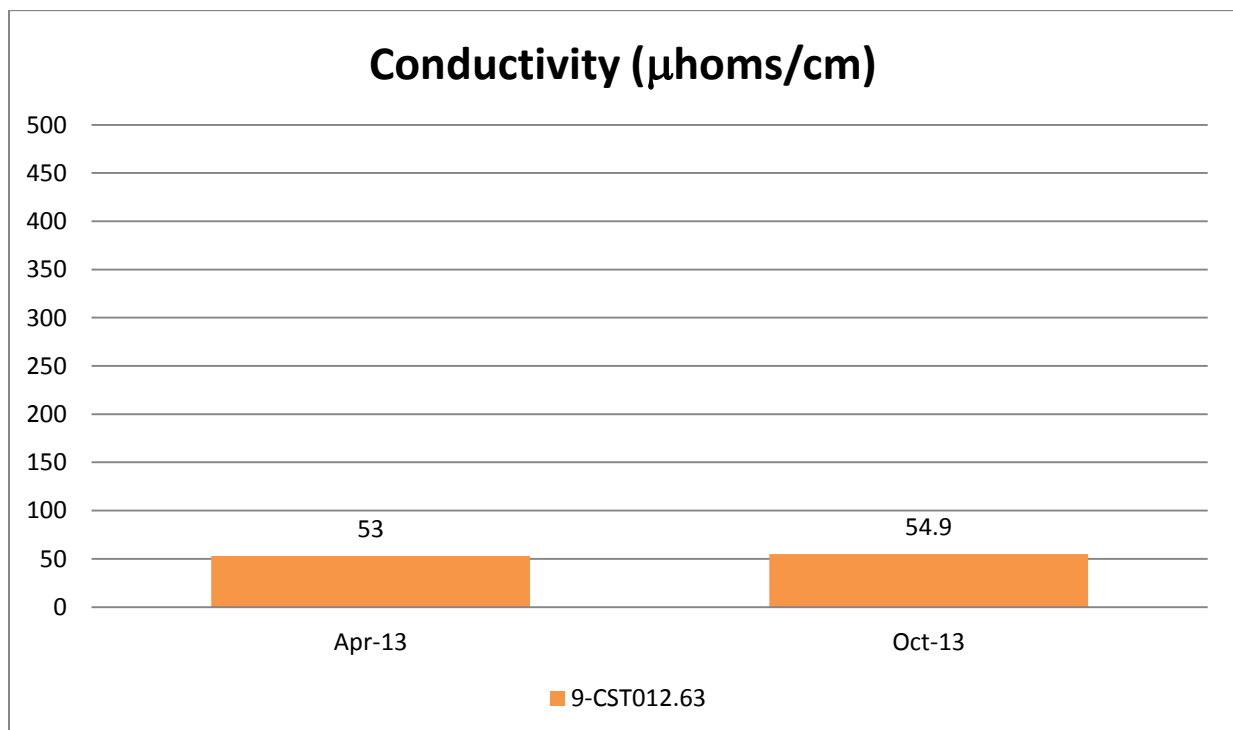


Figure 7 – Field Conductivity



The Stressor Analysis Report developed for Chestnut Creek lists the most probable stressor as sediment. Candidate stressors considered in the stressor analysis included dissolved oxygen, temperature, nutrients, toxics, metals, pH, and conductivity/total dissolved solids. A review of the available water quality data for the proposed nested segment indicates that field parameters are within expected ranges.

Sediment is supported as a probable stressor for these segments due to the suboptimal and marginal habitat metric related to sediment. Marginal bank stability along with the presence of fine sediments indicates sediment deposition. The impairment is relatively minor and sediment related habitat metrics are in the middle to low range, sediment seems to be the most probable cause of stress to the benthic community in Chestnut Creek.

The impairment on Chestnut Creek can be fully addressed through implementation of the Chestnut Creek TMDL.

Based on the rationale listed above, it is our recommendation that the above mentioned assessment unit be placed in Category 4A for the Aquatic Life Use.

Benthic TMDL Nesting Rationale
Levisa Fork, Buchanan County, Virginia

Completed TMDL Name: E.coli, Phased Benthic, and Phased Total PCB TMDL
Development for Levisa Fork, Slate Creek, and Garden Creek
Stream Name: Levisa Fork
TMDL Completion Date: 03/18/2011

Benthic Impaired Segments Included in the TMDL:

- 1) Assessment Unit ID: VAS-Q07R_SAT01A00
TMDL ID: 40006
Segment Length: 9.36 miles
Segment Description: Mainstem from the Upper Rockhouse Branch confluence near Matney downstream to the confluence with Levisa Fork in Grundy
- 2) Assessment Unit ID: VAS-Q04R_LEV01A94
TMDL ID: 40021
Segment Length: 3.95 miles
Segment Description: Mainstem from the confluence of Garden Creek, river mile 155.94 at Oakwood, to the confluence of Dismal Creek at the Route 460 crossing, river mile 151.84
- 3) Assessment Unit ID: VAS-Q06R_LEV01A98
TMDL ID: 40020
Segment Length: 8.26 miles
Segment Description: Mainstem from the Dismal Creek confluence, river mile 151.84m downstream to the Slate Creek confluence in Grundy, river mile 143.71
- 4) Assessment Unit ID: Q08R_LEV03A02
TMDL ID: 40023
Segment Length: 6.31 miles
Segment Description: From the Slate Creek confluence in Grundy downstream parallel to Route 460 to the Bull Creek confluence
- 5) Assessment Unit ID: VAS-Q08R_LEV01A00
TMDL ID: 40022
Segment Length: 2.68 miles
Segment Description: From Rocklick Branch at Big Rock downstream to the Kentucky state line

Segments for Nesting in the 2016 Integrated Assessment:

- 1) Assessment Unit ID: VAS-Q05R_DIS02A00
TMDL ID: Q05R-00-BEN, 40021
Segment Length: 9.14 miles
Segment Description: Headwaters of Dismal Creek near Redoak Ridge downstream through Jewell Valley and Whitewood to the Laurel Fork confluence
- 2) Assessment Unit ID: VAS-Q08R_HME01A04
TMDL ID: Q08R-02-BEN, 40022
Segment Length: 4.79 miles
Segment Description: Levisa Fork tributary south of Big Rock upstream to the Spencer Fork confluence

Justification for Nesting:

The *E.coli*, *Phased Benthic*, and *Phased Total PCB TMDL Development for Levisa Fork, Slate Creek, and Garden Creek* was completed in 2010 and approved by EPA on 03/18/2011. A comprehensive revision of this TMDL which includes both Phase I and Phase II was submitted to EPA on 07/02/2014. Figure 1 presents the Levisa Fork and Slate Creek TMDL watershed boundary, which includes Dismal Creek and Home Creek. The revised TMDL took into account and modeled all point and non-point sources of potential benthic stressors in the watershed. The process outlined in USEPA's Stressor Identification Guidance Document (USEPA, 2000) was used to identify the critical probable stressor(s) for the Levisa Fork. Analysis of physical, chemical, biological, and observational data indicated that sediment (TSS) was the most probable cause of the benthic impairment. Point sources discharging sediment were identified and given wasteload allocations (WLA) based on their issued Virginia Pollution Discharge Elimination System (VPDES) permits. Tables 11.9 and 11.10 from the revised TMDL lists the DMME and DEQ VPDES permits and associated WLAs for the TSS TMDL on the Levisa Fork. Permit tables from the TSS TMDL on Slate Creek are not shown since none of the proposed segments fall within the Slate Creek watershed.

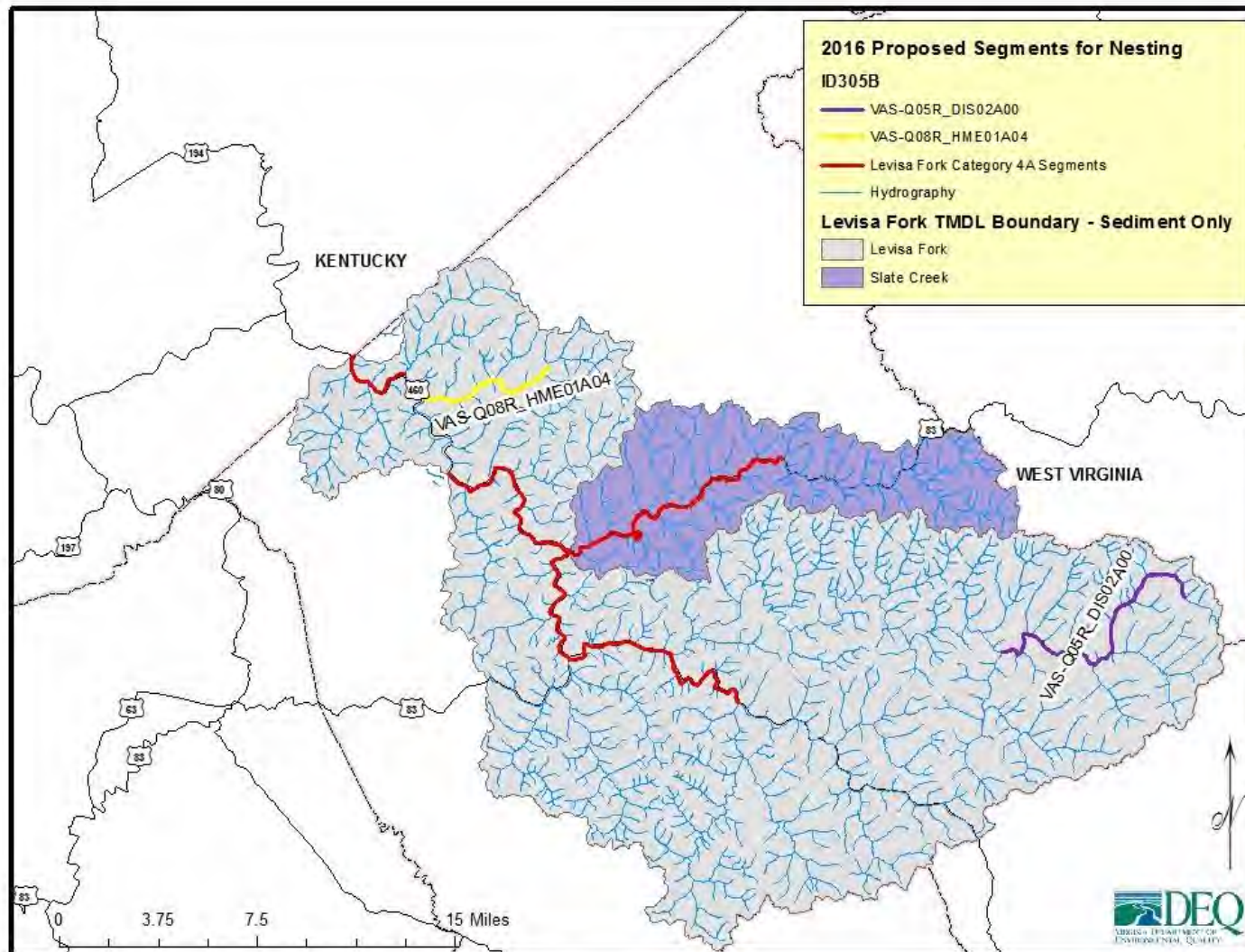


Figure 1 – Proposed Segments for Nesting

The land uses for the approved Levisa Fork TMDL area are comparable and consistent with the proposed nested segments. Data from the 2011 edition of the National Land Cover Database has been used to provide an updated and more accurate description of land uses in the watershed. Figure 2 presents land uses in Levisa Fork watershed.

Dismal Creek was first listed as impaired for aquatic life in 2016 and Home Creek was first listed in 2010. Both of the proposed nested segments fall within the watershed and TMDL boundary for the Levisa. The Dismal Creek impairment is based on DEQ biological monitoring data collected at a probabilistic monitoring station. Home Creek is based on data from a DEQ biological monitoring station. The locations for the monitoring stations are provided in Figure 3. Table 3 summarizes the DEQ data collected. Table 4 summarizes the benthic metrics. Table 5 summarizes the habitat data for the monitoring stations.

Chemical parameters include nitrogen and phosphorus. Water column metals were collected at 6ADIS022.34. Field physical parameters include temperature, pH, dissolved oxygen (DO), and conductivity. Plots of field parameters and other water chemistry are shown in figures 4-9. Water column metals are presented in Table 6. Where applicable, minimum and/or maximum water quality standards are indicated. Dismal Creek is a Class V Stockable Trout Water and Home Creek is a Class IV Mountainous Zone Water.

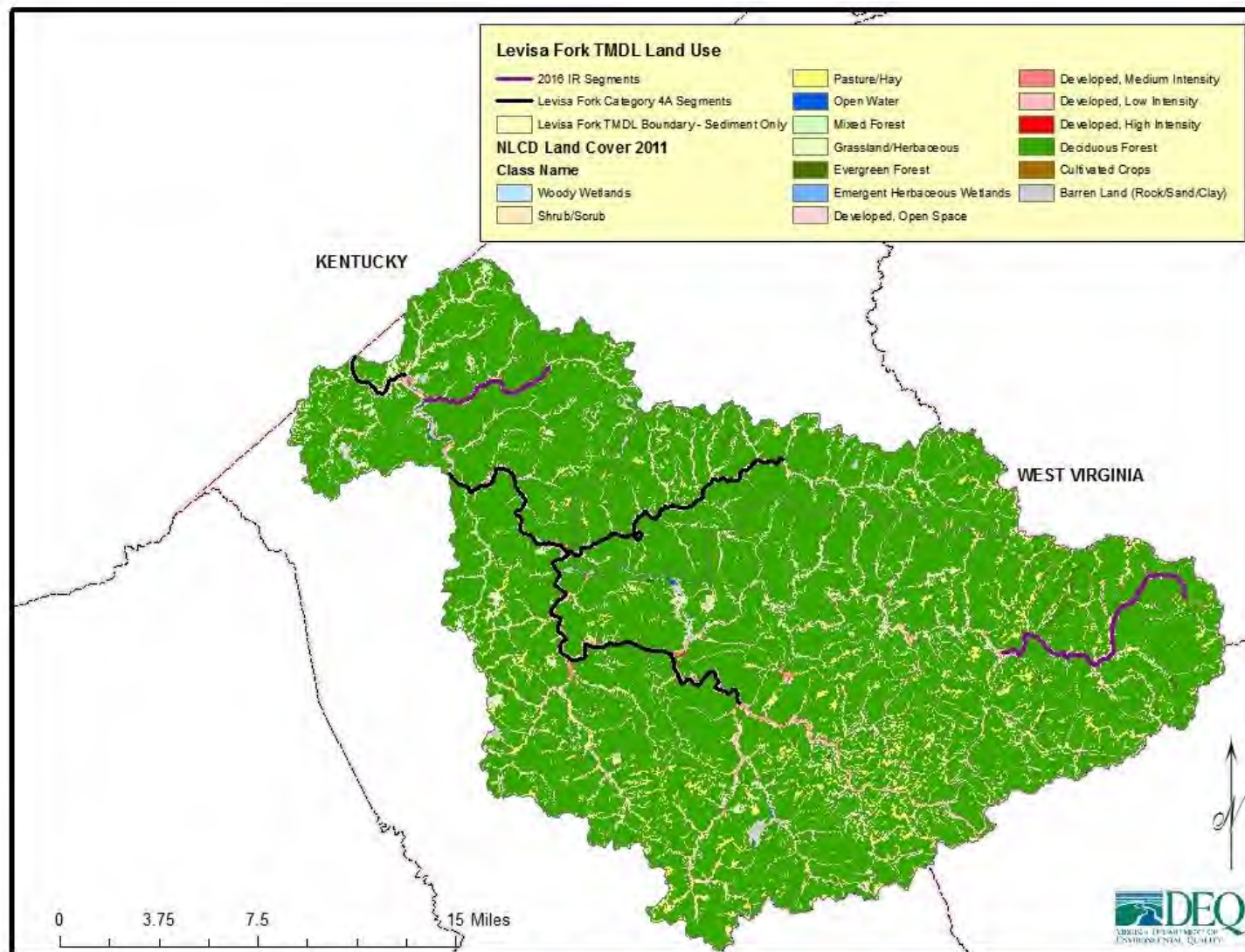


Figure 2 – Land use in the Levisa Fork TMDL Watershed

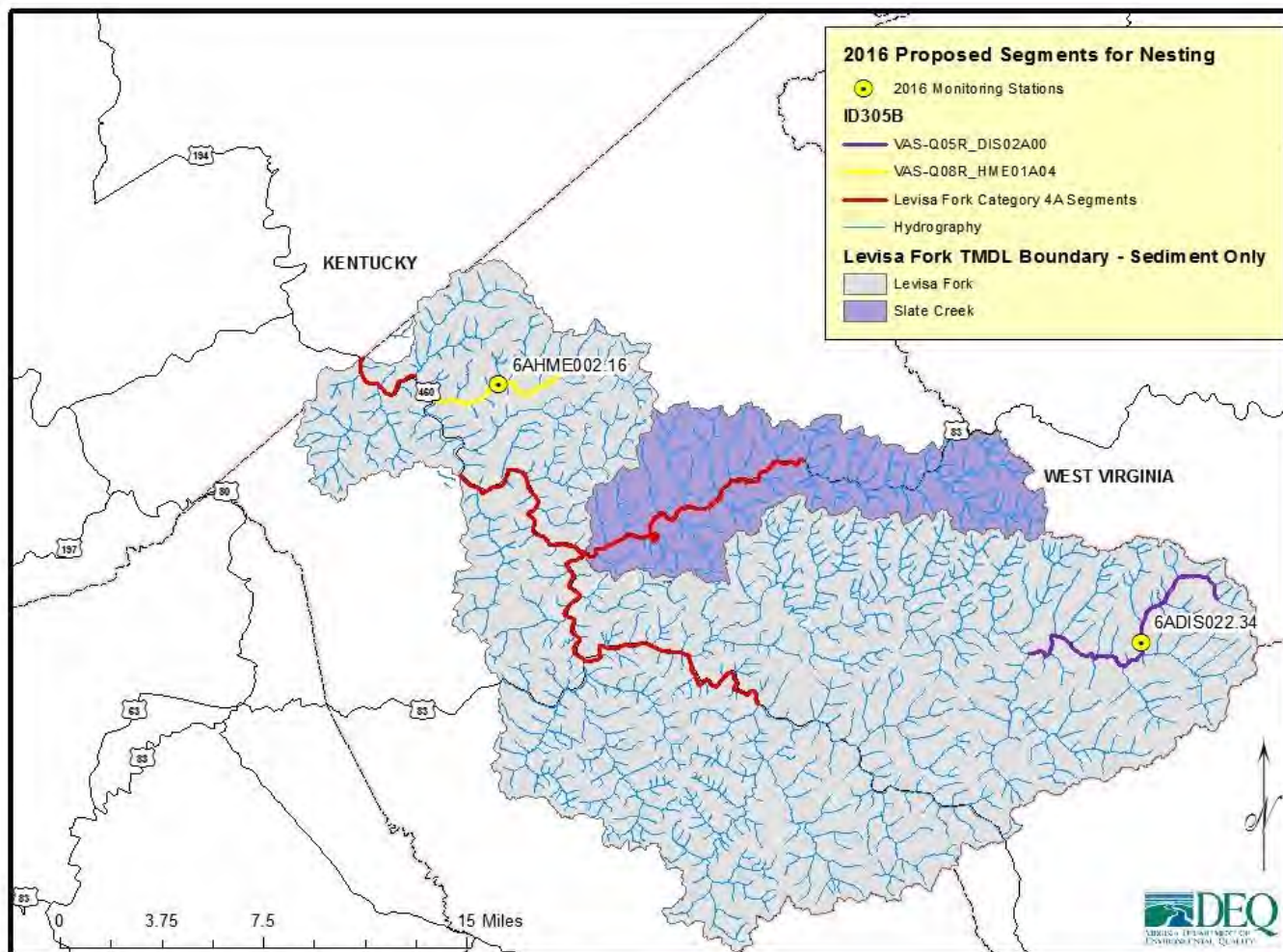


Figure 3 – Monitoring Stations for Proposed Nested Segments

Table 11.9 Average Annual Sediment TMDL for Levisa Fork

Impairment	WLA	LA	MOS	TMDL
	t/yr	t/yr	t/yr	t/yr
Levisa Fork	729.66	16,817.78	1,949.76	19,497.20
VAR101038	4.70			
VAR104503	0.86			
VAR102495	0.16			
VAR104799	0.19			
VAR050018	4.50			
VAR050059	0.54			
VAR050102	0.62			
VAR051686	1.73			
VAG110243	0.49			
VAG750020	0.41			
VAG400200	0.04			
VAG400573	0.04			
VAG400405	0.04			
VAG400741	0.04			
VAG400809	0.04			
VAG400404	0.04			
VAG400697	0.04			
VAG400589	0.04			
VAG400192	0.04			
VAG400129	0.04			
VAG400681	0.04			
VAG400682	0.04			
VAG400698	0.04			
VAG400830	0.04			
VAG400190	0.04			
VAG400191	0.04			
VAG400515	0.04			
VAG400211	0.04			
VAG400445	0.04			
VAG400549	0.04			
VAG400613	0.04			
VAG400413	0.04			
VAG400686	0.04			
VAG400727	0.04			
VAG400730	0.04			
VAG400825	0.04			
VAG400342	0.04			
VAG400678	0.04			
VAG400087	0.04			
VAG400108	0.04			

Impairment	WLA	LA	MOS	TMDL
	t/yr	t/yr	t/yr	t/yr
VAG400663	0.04			
VAG400729	0.04			
VAG400710	0.04			
VAG400680	0.04			
VA0050351	13.83			
VA0052639	0.04			
VA0065536	0.83			
VA0065625	1.04			
VA0066907	0.83			
VA0068438	0.30			
VA0089907	0.31			
VA0090239	0.13			
VA0090531	82.96			
<i>Future Growth</i>	<i>194.97</i>			
Surface Mining Transient	418.86			
<i>1100470</i>	<i>2.36</i>			
<i>1101381</i>	<i>18.85</i>			
<i>1101553</i>	<i>11.10</i>			
<i>1101752</i>	<i>24.92</i>			
<i>1101792</i>	<i>9.64</i>			
<i>1101846</i>	<i>7.80</i>			
<i>1101881</i>	<i>0.35</i>			
<i>1101903</i>	<i>1.47</i>			
<i>1101987</i>	<i>5.74</i>			
<i>1102001</i>	<i>17.57</i>			
<i>1102030</i>	<i>3.76</i>			
<i>1200194</i>	<i>1.68</i>			
<i>1200235</i>	<i>1.03</i>			
<i>1200282</i>	<i>0.24</i>			
<i>1200308</i>	<i>2.59</i>			
<i>1200335</i>	<i>0.09</i>			
<i>1200354</i>	<i>2.32</i>			
<i>1200881</i>	<i>0.28</i>			
<i>1201015</i>	<i>0.75</i>			
<i>1201050</i>	<i>0.40</i>			
<i>1201053</i>	<i>0.17</i>			
<i>1201091</i>	<i>2.13</i>			
<i>1201131</i>	<i>0.10</i>			
<i>1201182</i>	<i>1.54</i>			
<i>1201230</i>	<i>0.36</i>			
<i>1201273</i>	<i>0.97</i>			
<i>1201310</i>	<i>0.19</i>			
<i>1201345</i>	<i>0.56</i>			
<i>1201348</i>	<i>3.20</i>			

Impairment	WLA	LA	MOS	TMDL
	t/yr	t/yr	t/yr	t/yr
<i>1201373</i>	<i>0.11</i>			
<i>1201442</i>	<i>0.21</i>			
<i>1201484</i>	<i>0.78</i>			
<i>1201495</i>	<i>0.45</i>			
<i>1201508</i>	<i>0.52</i>			
<i>1201523</i>	<i>0.31</i>			
<i>1201532</i>	<i>0.14</i>			
<i>1201574</i>	<i>0.98</i>			
<i>1201698</i>	<i>0.14</i>			
<i>1201716</i>	<i>0.96</i>			
<i>1201749</i>	<i>0.59</i>			
<i>1201753</i>	<i>5.59</i>			
<i>1201902</i>	<i>0.79</i>			
<i>1201906</i>	<i>0.09</i>			
<i>1201907</i>	<i>0.20</i>			
<i>1202036</i>	<i>0.43</i>			
<i>1300120</i>	<i>1.26</i>			
<i>1300359</i>	<i>5.88</i>			
<i>1300378</i>	<i>0.76</i>			
<i>1300379</i>	<i>3.44</i>			
<i>1300398</i>	<i>1.52</i>			
<i>1300404</i>	<i>1.14</i>			
<i>1300417</i>	<i>1.24</i>			
<i>1300425</i>	<i>11.26</i>			
<i>1300426</i>	<i>18.00</i>			
<i>1300451</i>	<i>1.79</i>			
<i>1300453</i>	<i>14.53</i>			
<i>1300454</i>	<i>2.52</i>			
<i>1300945</i>	<i>0.25</i>			
<i>1301156</i>	<i>1.20</i>			
<i>1301226</i>	<i>13.44</i>			
<i>1400047</i>	<i>79.20</i>			
<i>1400345</i>	<i>4.38</i>			
<i>1400419</i>	<i>0.95</i>			
<i>1400492</i>	<i>16.14</i>			
<i>1400493</i>	<i>8.26</i>			
<i>1400496</i>	<i>9.03</i>			
<i>1400498</i>	<i>5.46</i>			
<i>1401039</i>	<i>1.37</i>			
<i>1401167</i>	<i>2.61</i>			
<i>1401181</i>	<i>0.69</i>			
<i>1401232</i>	<i>5.10</i>			
<i>1401489</i>	<i>9.66</i>			
<i>1401493</i>	<i>1.44</i>			

Impairment	WLA	LA	MOS	TMDL
	t/yr	t/yr	t/yr	t/yr
<i>1401531</i>	<i>10.45</i>			
<i>1401598</i>	<i>4.65</i>			
<i>1401635</i>	<i>3.67</i>			
<i>1500384</i>	<i>5.82</i>			
<i>1601787</i>	<i>19.31</i>			
<i>1601816</i>	<i>6.08</i>			
<i>1700864</i>	<i>5.87</i>			
<i>1701300</i>	<i>6.02</i>			
<i>1801821</i>	<i>0.02</i>			

Table 11.10 Maximum Daily Sediment TMDL for Levisa Fork

Impairment	WLA	LA	MOS	TMDL
	t/day	t/ day	t/ day	t/ day
Levisa Fork	1.999	125.40	14.16	141.56
VAR101038	0.0129			
VAR104503	0.0024			
VAR102495	0.0004			
VAR104799	0.0005			
VAR050018	0.0123			
VAR050059	0.0015			
VAR050102	0.0017			
VAR051686	0.0047			
VAG110243	0.0013			
VAG750020	0.0011			
VAG400200	0.0001			
VAG400573	0.0001			
VAG400405	0.0001			
VAG400741	0.0001			
VAG400809	0.0001			
VAG400404	0.0001			
VAG400697	0.0001			
VAG400589	0.0001			
VAG400192	0.0001			
VAG400129	0.0001			
VAG400681	0.0001			
VAG400682	0.0001			
VAG400698	0.0001			
VAG400830	0.0001			
VAG400190	0.0001			
VAG400191	0.0001			
VAG400515	0.0001			
VAG400211	0.0001			
VAG400445	0.0001			
VAG400549	0.0001			
VAG400613	0.0001			
VAG400413	0.0001			
VAG400686	0.0001			
VAG400727	0.0001			
VAG400730	0.0001			
VAG400825	0.0001			
VAG400342	0.0001			
VAG400678	0.0001			
VAG400087	0.0001			
VAG400108	0.0001			

Impairment	WLA	LA	MOS	TMDL
	t/day	t/ day	t/ day	t/ day
VAG400663	0.0001			
VAG400729	0.0001			
VAG400710	0.0001			
VAG400680	0.0001			
VA0050351	0.0379			
VA0052639	0.0001			
VA0065536	0.0023			
VA0065625	0.0028			
VA0066907	0.0023			
VA0068438	0.0008			
VA0089907	0.0008			
VA0090239	0.0004			
VA0090531	0.2273			
<i>Future Growth</i>	0.5342			
Surface Mining Transient	1.1476			
1100470	0.0065			
1101381	0.0516			
1101553	0.0304			
1101752	0.0683			
1101792	0.0264			
1101846	0.0214			
1101881	0.0010			
1101903	0.0040			
1101987	0.0157			
1102001	0.0481			
1102030	0.0103			
1200194	0.0046			
1200235	0.0028			
1200282	0.0007			
1200308	0.0071			
1200335	0.0002			
1200354	0.0064			
1200881	0.0008			
1201015	0.0021			
1201050	0.0011			
1201053	0.0005			
1201091	0.0058			
1201131	0.0003			
1201182	0.0042			
1201230	0.0010			
1201273	0.0027			
1201310	0.0005			
1201345	0.0015			
1201348	0.0088			

Impairment	WLA	LA	MOS	TMDL
	t/day	t/ day	t/ day	t/ day
1201373	0.0003			
1201442	0.0006			
1201484	0.0021			
1201495	0.0012			
1201508	0.0014			
1201523	0.0008			
1201532	0.0004			
1201574	0.0027			
1201698	0.0004			
1201716	0.0026			
1201749	0.0016			
1201753	0.0153			
1201902	0.0022			
1201906	0.0002			
1201907	0.0005			
1202036	0.0012			
1300120	0.0035			
1300359	0.0161			
1300378	0.0021			
1300379	0.0094			
1300398	0.0042			
1300404	0.0031			
1300417	0.0034			
1300425	0.0308			
1300426	0.0493			
1300451	0.0049			
1300453	0.0398			
1300454	0.0069			
1300945	0.0007			
1301156	0.0033			
1301226	0.0368			
1400047	0.2170			
1400345	0.0120			
1400419	0.0026			
1400492	0.0442			
1400493	0.0226			
1400496	0.0247			
1400498	0.0150			
1401039	0.0038			
1401167	0.0072			
1401181	0.0019			
1401232	0.0140			
1401489	0.0265			
1401493	0.0039			

Impairment	WLA	LA	MOS	TMDL
	t/day	t/ day	t/ day	t/ day
<i>1401531</i>	<i>0.0286</i>			
<i>1401598</i>	<i>0.0127</i>			
<i>1401635</i>	<i>0.0101</i>			
<i>1500384</i>	<i>0.0159</i>			
<i>1601787</i>	<i>0.0529</i>			
<i>1601816</i>	<i>0.0167</i>			
<i>1700864</i>	<i>0.0161</i>			
<i>1701300</i>	<i>0.0165</i>			
<i>1801821</i>	<i>0.0001</i>			

Table 3 – Nested Segments Biological Monitoring Scores

Station ID	Stream Name	Assessment Unit ID	Date Sample Taken	Virginia Stream Condition Index Score (VSCI)
6ADIS022.34	Dismal Creek	VAS-Q05R_DIS02A00	10/1/2013	48.84
6ADIS022.34	Dismal Creek	VAS-Q05R_DIS02A00	04/11/2013	52.93
6AHME002.16	Home Creek	VAS-Q08R_HME01A04	10/21/2013	55.76
6AHME002.16	Home Creek	VAS-Q08R_HME01A04	04/15/2013	22.66

Table 4 – Benthic Metrics

Station ID	6ADIS022.34		6AHME002.16	
Metric	04/11/2013	10/01/2013	4/15/2013	10/21/2013
Richness Score	45.45	54.55	27.27	72.73
EPT Score	63.64	54.55	18.18	63.64
% Ephem Score	57.84	34.11	20.76	23.73
% P+T-H Score	12.77	5.11	0.00	7.66
% Scraper Score	24.67	31.71	0.00	21.82
% Chironomidae Score	71.82	97.27	29.09	93.64
% 2 Dom. Score	72.25	42.04	23.65	57.80
% MFBI Score	75.00	71.39	62.36	70.94

Table 5 – Habitat Evaluation for Dismal Creek and Home Creek

Habitat Metrics					
	Station ID	6ADIS022.34		6AHME002.16	
	Collection Date	04/11 2013	10/01 2013	04/15 2013	10/21 2013
Channel Alteration	ALTER	18	19	16	15
Bank Stability	BANKS	14	14	10	14
Bank Vegetation	BANKVEG	14	17	13	16
Embeddedness	EMBED	14	13	13	13
Channel Flow Status	FLOW	17	14	18	14
Frequency of Riffles	RIFFLES	16	16	16	16
Riparian Vegetation	RIPVEG	14	18	14	15
Sediment Deposition	SEDIMENT	9	11	10	12
Substrate Availability	SUBSTRATE	18	18	16	17
Velocity/Depth Regime	VELOCITY	15	10	15	15
10-Metric Total		149	150	141	147

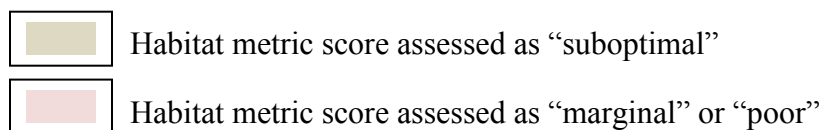


Figure 4 – Field Temperature

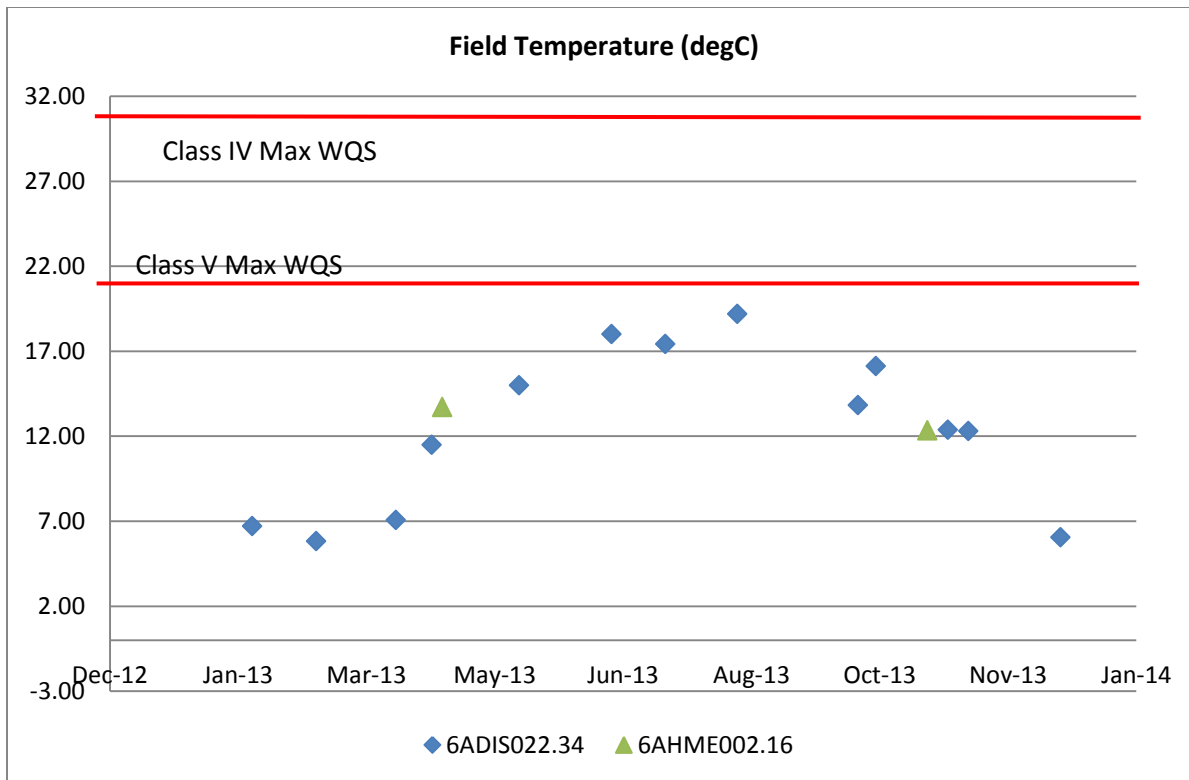


Figure 5 – Field pH

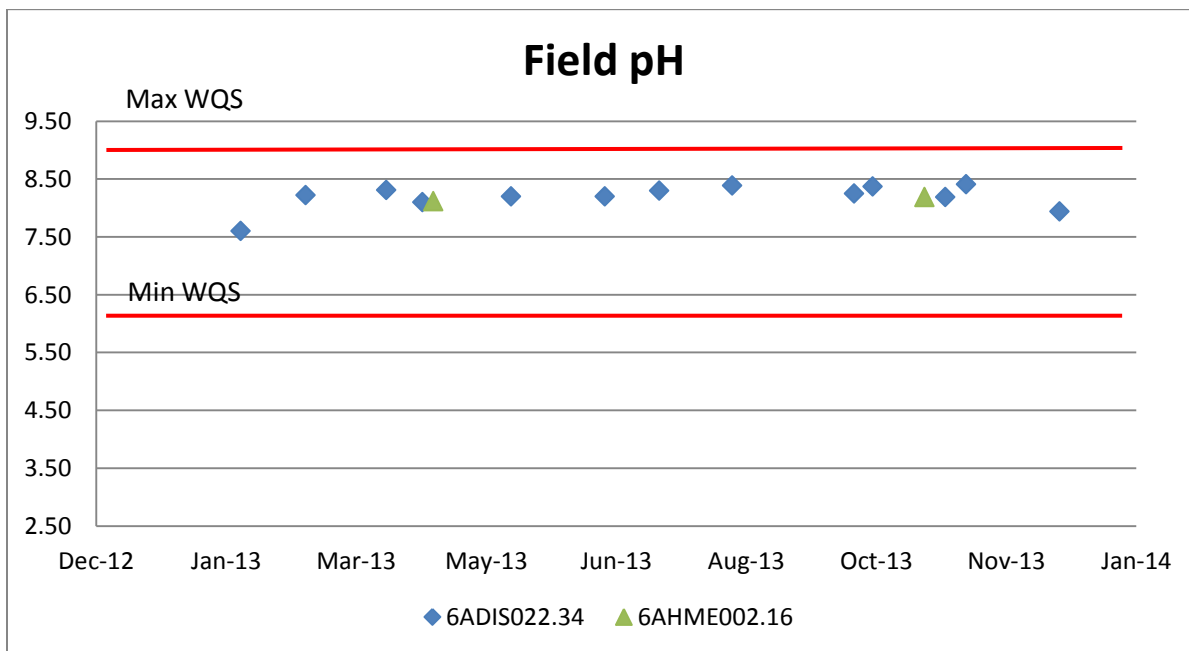


Figure 6 – Field DO

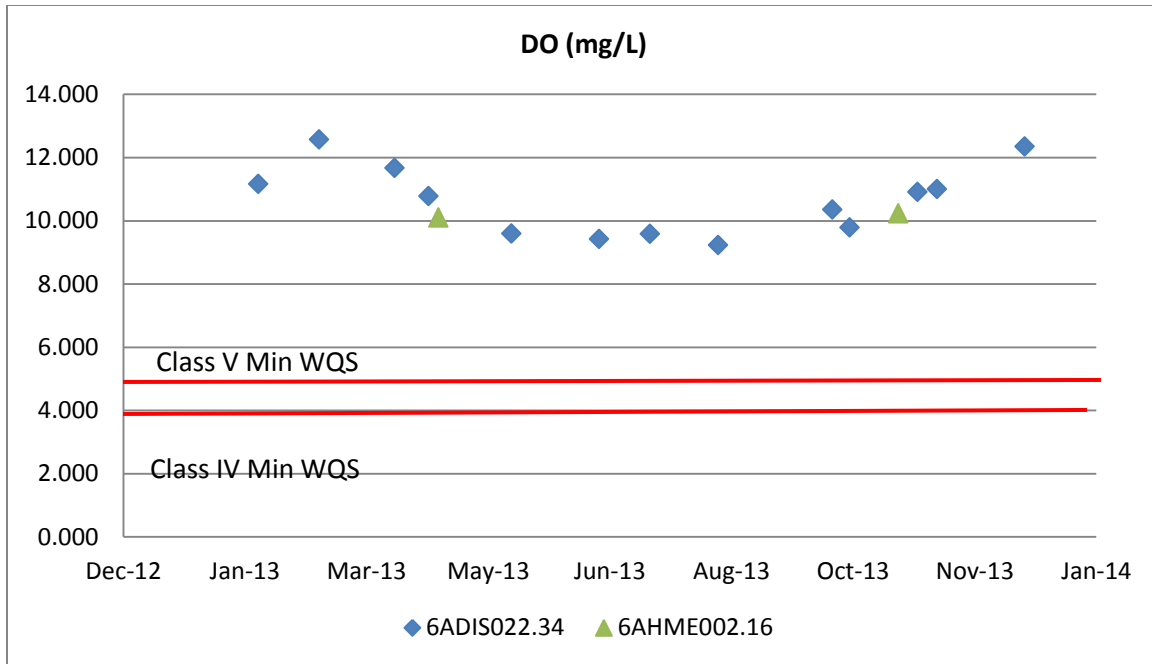


Figure 7 – Field Conductivity

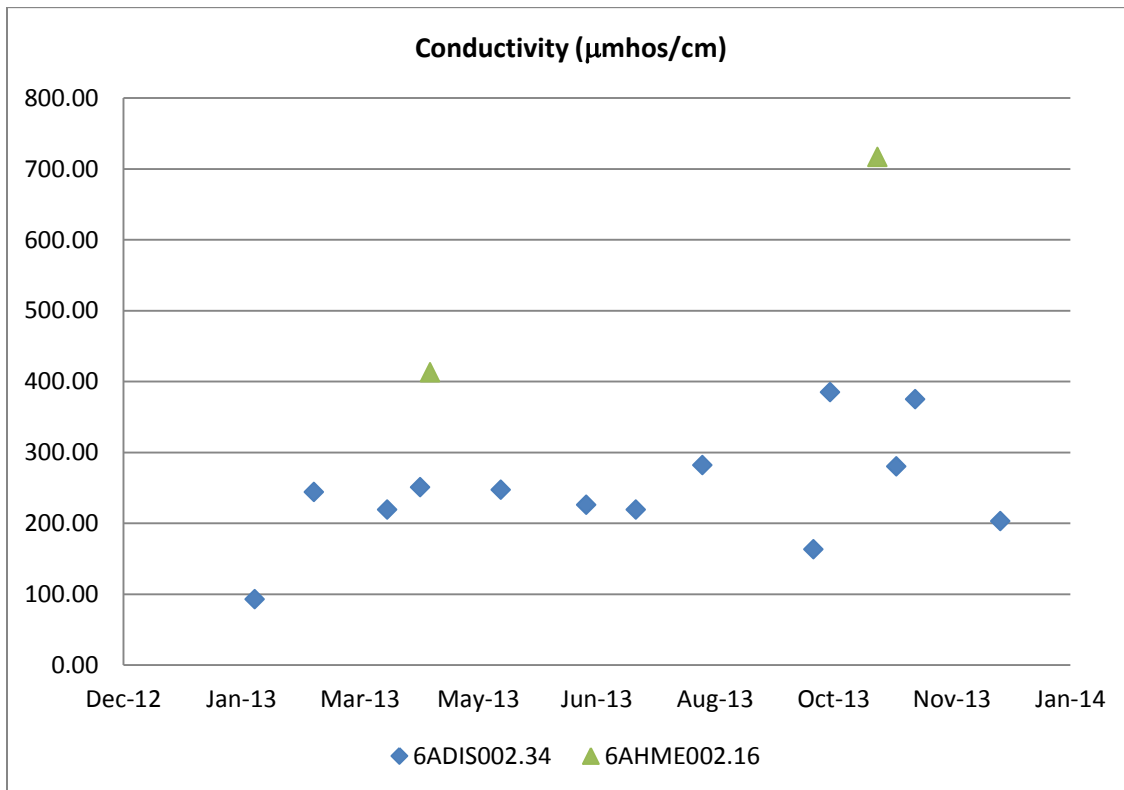


Figure 8 – Total Nitrogen

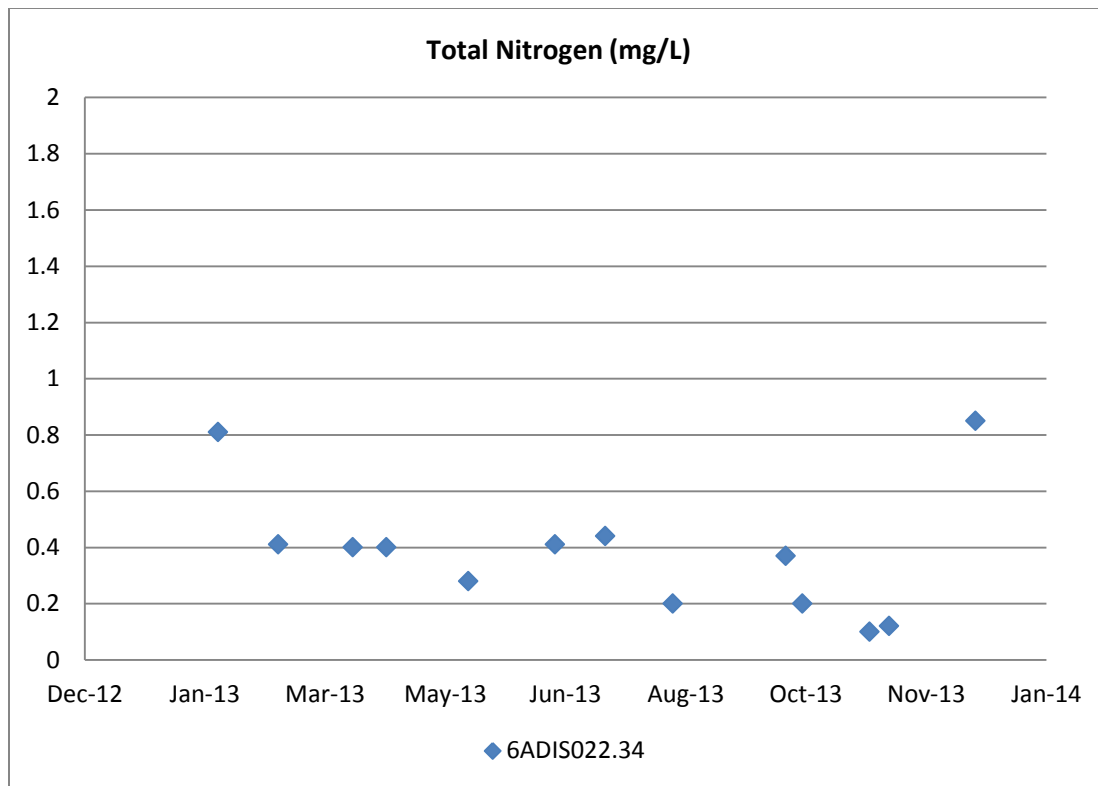


Figure 9 – Total Phosphorus

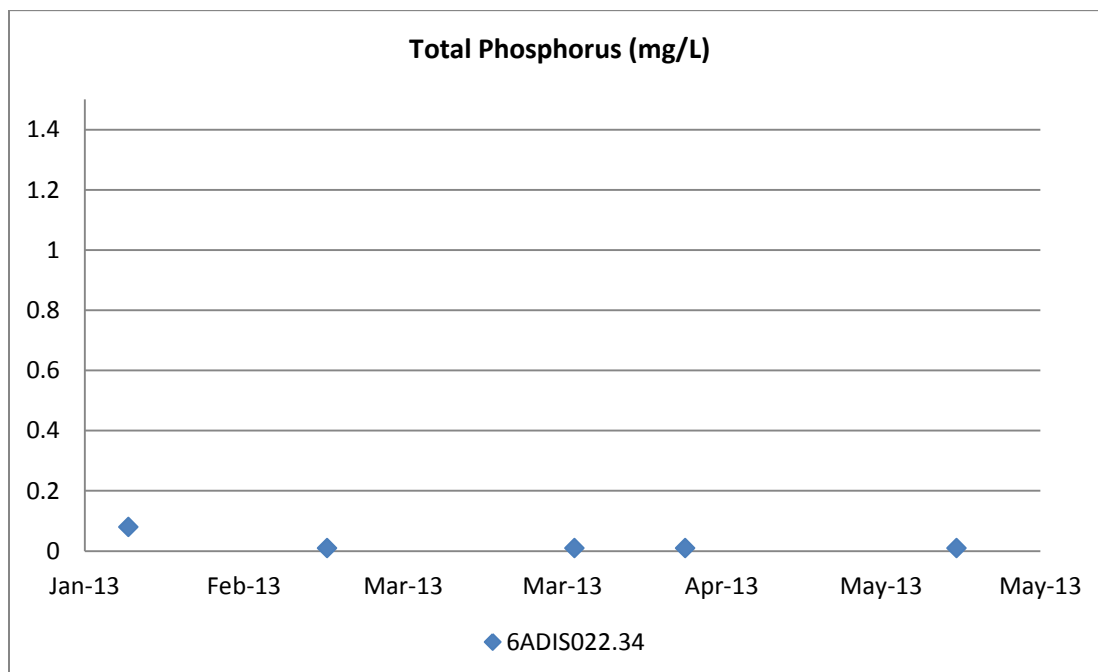


Table 6 – Water Column Metals

Parameter Name	Pgc Spc Parm	6ADIS022.34	Freshwater Aquatic Life Criteria~		Human Health Criteria~	
			Chronic (ug/L)	Acute (ug/L)	PWS (ug/L)	Other (ug/L)
Arsenic, Dissolved (UG/L as AS)	01000	0.2	150	340	10	
Barium, Total (UG/L as BA)	01005	26.7000			2,000	
Cadmium, Dissolved (UG/L as CD)	01025	0.12	1.1	3.9	5	
Chromium, Dissolved (UG/L as CR)	01030	0.3000	74	570	100	
Copper, Dissolved (UG/L as CU_)	01040	0.5900	9	13	1,300	
Lead, Dissolved (UG/L as PB)	01049	0.01	11	94	15	
Thallium, Dissolved (UG/L as TL)	01057	0.0200			0.24	0.47
Nickel, Dissolved (UG/L as NI)	01065	11.61	20	180	610	4,600
Silver, Dissolved (UG/L as AG)	01075	-0.0200				
Zinc, Dissolved (UG/L as ZN)	01090	8.1300	120	120	7,400	26,000
Antimony, Dissolved (UG/L as SB)	01095	0.0600			5.6	640
Selenium, Dissolved (UG/L as SE)	01145	1.8200	5	20	170	4,200
Mercury – TL, Filtered Water, Ultratrace method (NG/L)	50091	0.0004				
Hardness, CA MG (MG/L as CaCO3) as Dissolved	DHARD	354				

~9VAC25-260 Virginia Water Quality Standards, June 5, 2017.

The Stressor Analysis Report developed for the Levisa Fork Phased TMDLs lists the most probable stressor for the Levisa Fork as sediment. Candidate stressors considered in the stressor analysis included ammonia, hydrologic modifications, nutrients, organic matter, pH, sediment, TDS/conductivity/sulfates, temperature, and toxics. A review of the available water quality data for the proposed nested segment indicates that chemical parameters and field parameters are within expected ranges. Conductivity is elevated but remains at levels lower than those present when the TMDL was developed.

Sediment is supported as a probable stressor for these segments due to the suboptimal and marginal habitat metric related to sediment. Marginal bank stability along with the presence of fine sediments indicates sediment deposition. The impairment is relatively minor and sediment related habitat metrics are in the middle range, sediment seems to be the most probable cause of stress to the benthic community in Dismal Creek and Home Creek.

The impairment on the Dismal Creek and Home Creek can be fully addressed through implementation of the Levisa Fork TMDL.

Based on the rationale listed above, it is our recommendation that the above mentioned assessment units be placed in Category 4A for the Aquatic Life Use.

Benthic TMDL Nesting Rationale
Powell River, Lee and Wise Counties, Virginia

Completed TMDL Name: E. coli and Phased Benthic Total Maximum Daily Load for Powell River and Tributaries (North Fork Powell River, South Fork Powell River, Butcher Fork, and Wallen Creek)
Stream Name: Powell River
TMDL Completion Date: 03/10/2011

Benthic Impaired Segments Included in the TMDL:

- 1) Assessment Unit ID: VAS-P18R_PLL01A02
TMDL ID: 39848
Segment Length: 1.97 miles
Segment Description: Mainstem from the confluence of Beaverdam Creek downstream to the Butcher Fork confluence at East Stone Gap
- 2) Assessment Unit ID: VAS-P18R_PLL01A98
TMDL ID: 39849
Segment Length: 3.83 miles
Segment Description: Mainstem from the Butcher Fork confluence north of East Stone Gap downstream to the confluence with the Powell River at Three Forks in Big Stone Gap
- 3) Assessment Unit ID: VAS-P20R_PWL01A00
TMDL ID: 39850
Segment Length: 6.05 miles
Segment Description: From the Straight Creek confluence at rivermile 6.25, through Pennington Gap, downstream to the Powell River confluence
- 4) Assessment Unit ID: P17R_POW01A94
TMDL ID: 39851
Segment Length: 2.71 miles
Segment Description: Powell River from the Roaring Branch confluence at rivermile 180.83, downstream to Dakota Street in Big Stone Gap at rivermile 177.53, this segment includes Callahan Creek
- 5) Assessment Unit ID: VAS-P19R_POW03A00
TMDL ID: 39852
Segment Length: 6.62 miles
Segment Description: Near Dryden from the confluence of Poor Valley Creek downstream to Public Water Supply segment in WQS Section 1

- 6) Assessment Unit ID: VAS-P23R_POW02A00
TMDL ID: 39847
Segment Length: 8.47 miles
Segment Description: From Hardy Creek near White Shoals downstream to the Yellow Creek confluence

Segments for Nesting in the 2016 Integrated Assessment:

- 1) Assessment Unit ID: VAS-P17R_PIG01B12
TMDL ID: P17R-07-BEN, 39851
Segment Length: 3.42 miles
Segment Description: Headwaters from Little Black Mountain, the Kentucky line, through the Exeter community downstream to the Laurel Fork confluence

Segments Approved for Nesting in the 2014 Integrated Assessment:

- 1) Assessment Unit ID: VAS-P17R_POW03C14
TMDL ID: 39851
Segment Length: 1.57 miles
Segment Description: Headwaters of the mainstem Powell River

Justification for Nesting:

The *E. coli and Phased Benthic Total Maximum Daily Load for Powell River and Tributaries (North Fork Powell River, South Fork Powell River, Butcher Fork, and Wallen Creek)* was completed in 2010 and approved by EPA on 03/10/2011. A comprehensive revision of this TMDL which includes both Phase I and Phase II was submitted to EPA on 07/02/2014. Figure 1 presents the Powell River and Tributaries TMDL watershed boundary, which includes Pigeon Creek. The revised TMDL took into account and modeled all point and non-point sources of potential benthic stressors in the watershed. The process outlined in USEPA's Stressor Identification Guidance Document (USEPA, 2000) was used to identify the critical probable stressor(s) for the Powell River. Analysis of physical, chemical, biological, and observational data indicated that sediment (TSS) was the most probable cause of the benthic impairment. Point sources discharging sediment were identified and given wasteload allocations (WLA) based on their issued Virginia Pollution Discharge Elimination System (VPDES) permits. Table 12-4 and Table 12-5 from the revised TMDL lists the DMME and DEQ VPDES permits and associated WLAs for the TSS TMDL. Any permits located on nested segments were captured in the original TMDL.

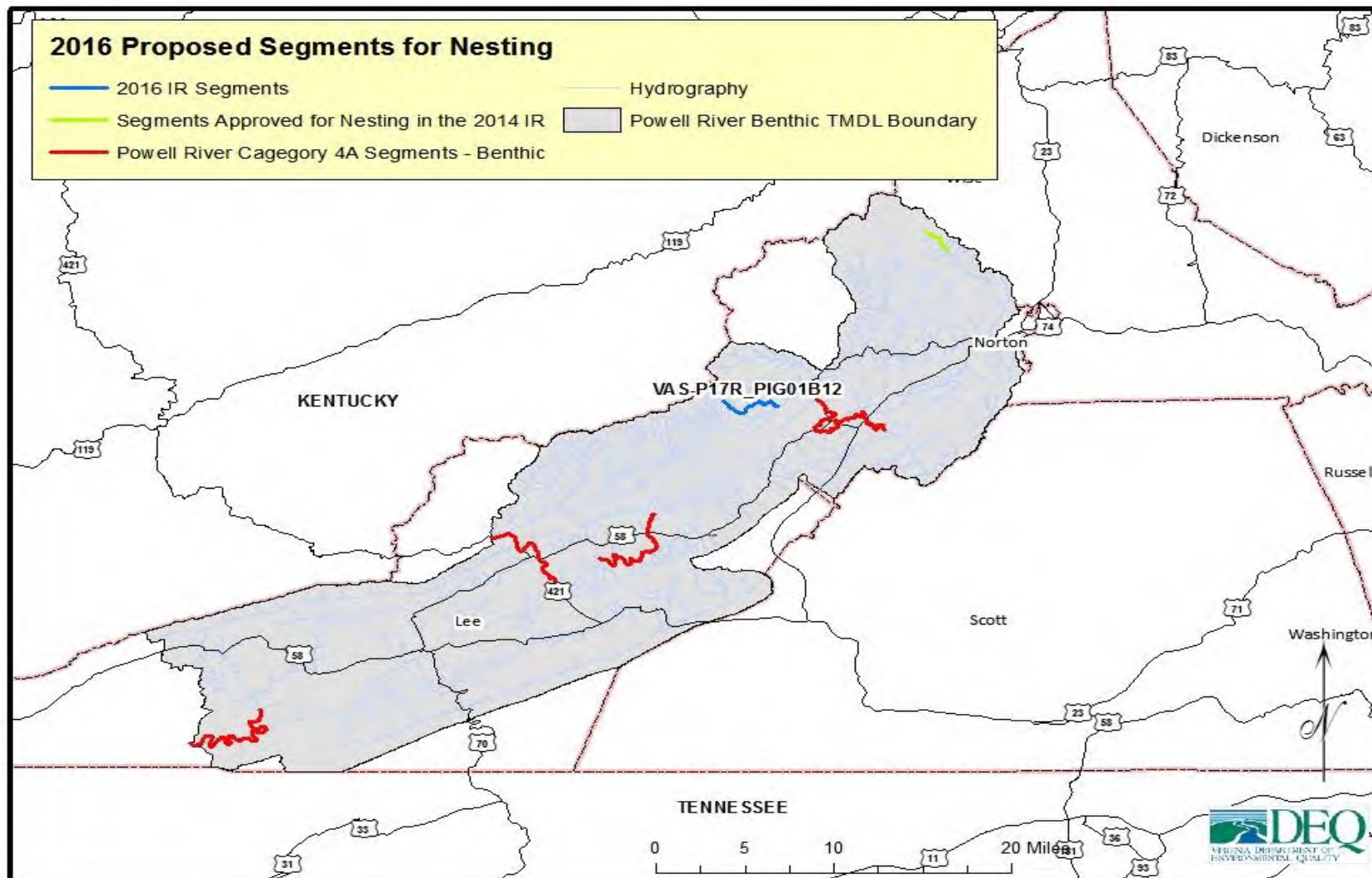


Figure 1 – Proposed Segments for Nesting

The land uses for the approved Powell River TMDL area are comparable and consistent with the proposed nested segments. Data from the 2011 edition of the National Land Cover Database has been used to provide an updated and more accurate description of land uses in the watershed. Figure 2 presents land uses in Powell River watershed.

Pigeon Creek was first listed as impaired in 2012. The proposed nested segment falls within both the watershed and TMDL boundary for the Powell River. The impairment is based on DEQ biological monitoring data. The location for the monitoring station is provided in Figure 3. Table 3 summarizes the DEQ data collected. Table 4 summarizes the benthic metrics. Table 5 summarizes the habitat data for the monitoring stations.

Field physical parameters include temperature, pH, dissolved oxygen (DO), and conductivity. Plots of field parameters are shown in figures 4-7. Where applicable, minimum and/or maximum water quality standards are indicated. Pigeon Creek is a Class IV Mountainous Zone Water.

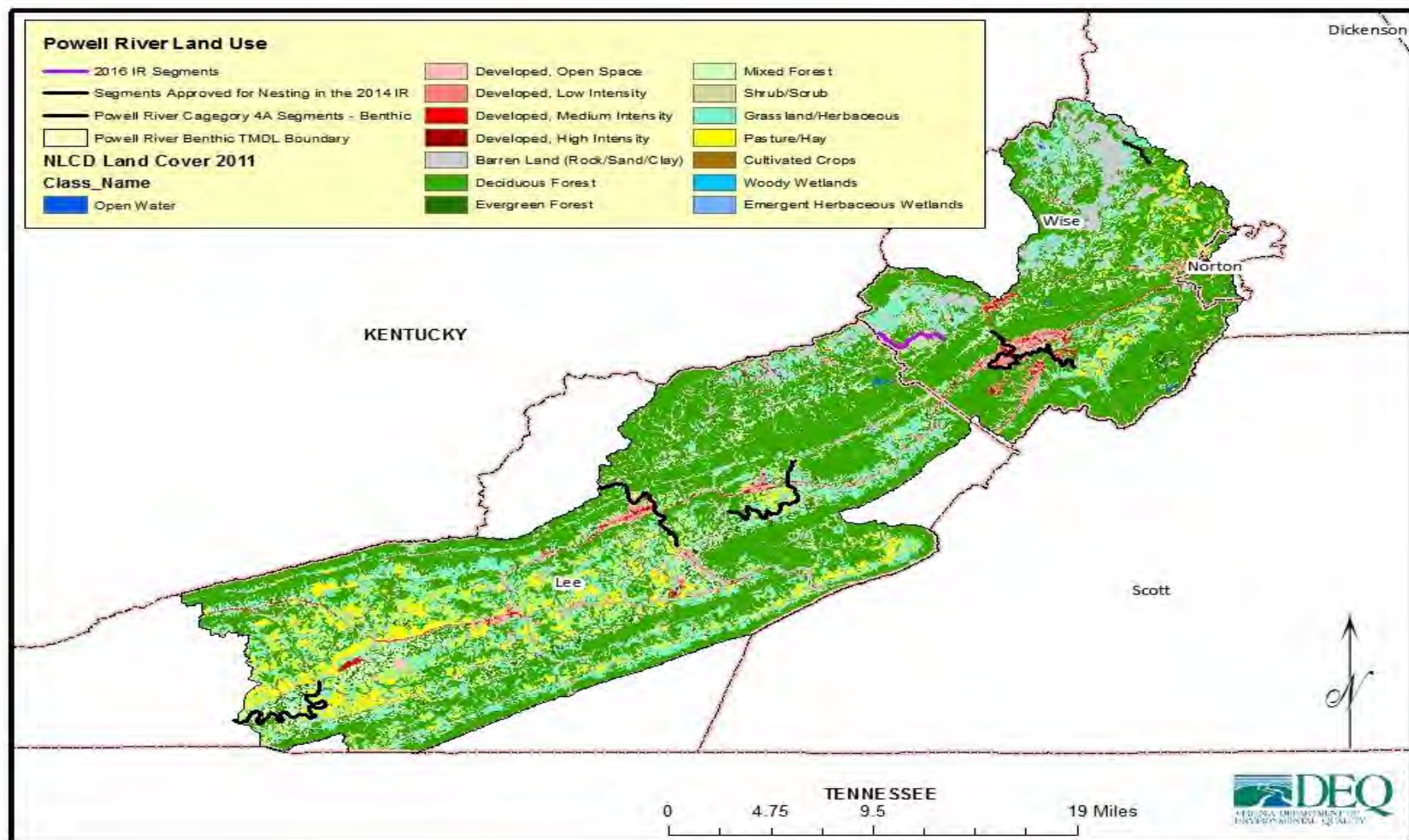


Figure 2 – Land use in the Powell River TMDL Watershed

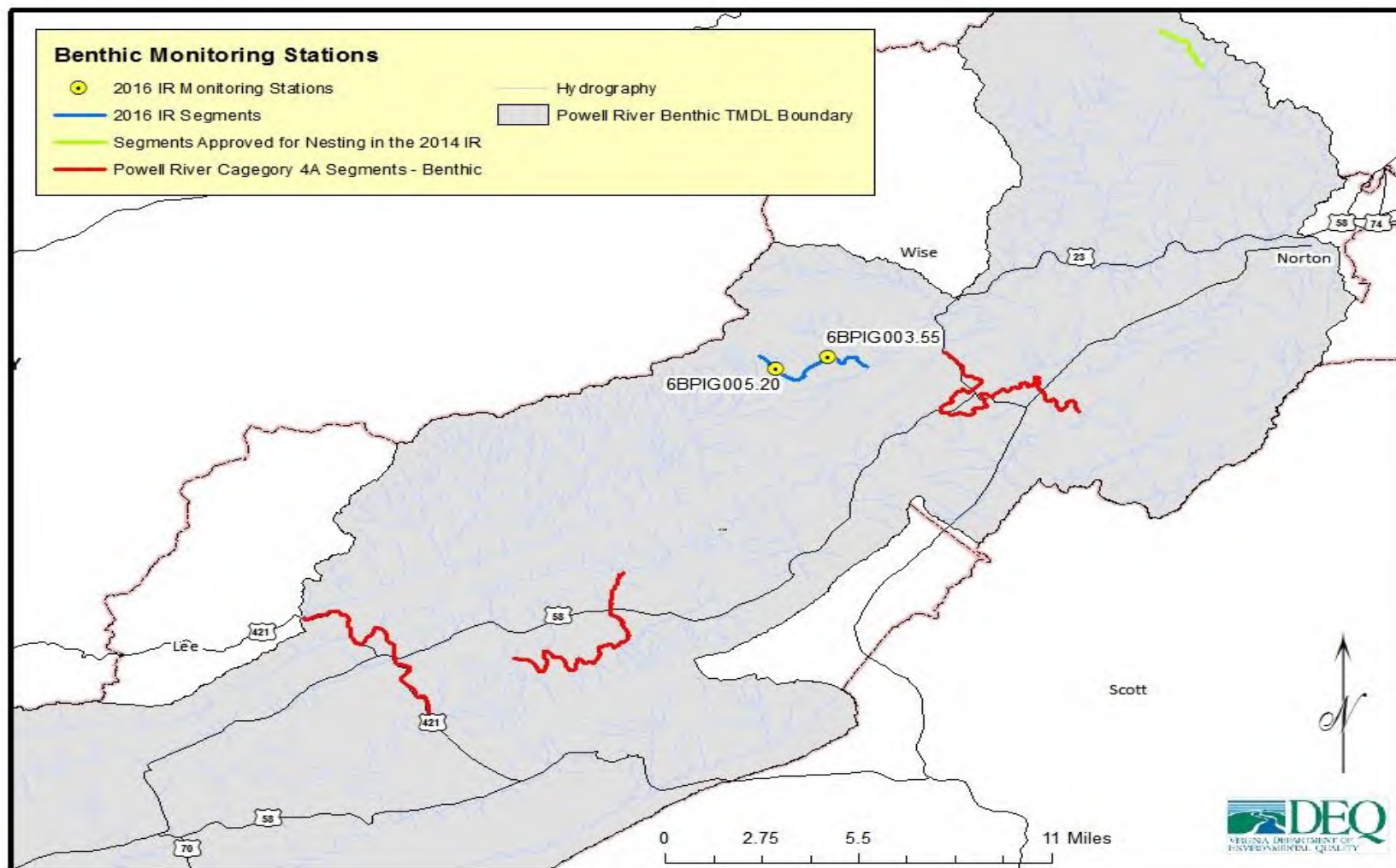


Figure 3 – Monitoring Stations for Proposed Nested Segments

Table 12-4 Average Annual Sediment TMDL

Impairment	WLA t/yr	LA t/yr	MOS t/yr	TMDL t/yr
Powell River	7,416.93	50,117.77	6,392.74	63,927.44
<i>DEQ VPDES permits:</i>				
VAG750004	0.41			
VAG750024	0.41			
VA0020940	82.95			
VA0029599	24.88			
VA0052311	2.03			
VA0052337	2.03			
VA0053023	5.60			
VA0060798	0.50			
VA0063941	0.20			
VA0070751	14.10			
VA0075515	1.24			
VA0089397	33.18			
VAG110005	0.14			
VAG110210	0.14			
VAR050060	0.14			
VAR050065	0.14			
VAR050067	0.14			
VAR050131	0.14			
VAR050157	0.14			
VAR051276	0.14			
VAR051779	0.14			
VAG840005	0.14			
VAG840005	0.14			
VAG840005	0.14			
VAG840015	0.14			
VAR103405	1.58			
VAR101845	0.81			
VAR101845	0.81			
VAR101845	0.81			
VAR101845	0.81			
VAR104287	0.80			
VAR104305	0.80			
VAR104475	0.81			
VAR102769	0.81			
VAR104500	0.80			
VAR104502	0.80			
<i>subtotal</i>	<i>178.99</i>			

Impairment	WLA t/yr	LA t/yr	MOS t/yr	TMDL t/yr
<i>DMME Mining Permits:</i>				
<i>1100033</i>	<i>41.25</i>			
<i>1100439</i>	<i>10.03</i>			
<i>1100583</i>	<i>6.75</i>			
<i>1100584</i>	<i>0.83</i>			
<i>1100735</i>	<i>3.81</i>			
<i>1100877</i>	<i>7.74</i>			
<i>1101350</i>	<i>14.97</i>			
<i>1101554</i>	<i>3.07</i>			
<i>1101565</i>	<i>3.52</i>			
<i>1101661</i>	<i>18.12</i>			
<i>1101760</i>	<i>76.05</i>			
<i>1101800</i>	<i>9.04</i>			
<i>1101804</i>	<i>42.12</i>			
<i>1101813</i>	<i>14.74</i>			
<i>1101824</i>	<i>4.37</i>			
<i>1101905</i>	<i>40.88</i>			
<i>1101918</i>	<i>24.64</i>			
<i>1101954</i>	<i>58.85</i>			
<i>1101975</i>	<i>15.04</i>			
<i>1101991</i>	<i>15.87</i>			
<i>1102011</i>	<i>16.49</i>			
<i>1102028</i>	<i>18.05</i>			
<i>1102031</i>	<i>2.95</i>			
<i>1201589</i>	<i>0.69</i>			
<i>1201680</i>	<i>0.17</i>			
<i>1201803</i>	<i>0.62</i>			
<i>1201875</i>	<i>0.97</i>			
<i>1201921</i>	<i>0.69</i>			
<i>1201949</i>	<i>1.23</i>			
<i>1202015</i>	<i>0.32</i>			
<i>1301430</i>	<i>0.49</i>			
<i>1301533</i>	<i>2.77</i>			
<i>1301561</i>	<i>2.38</i>			
<i>1301590</i>	<i>0.92</i>			
<i>1301687</i>	<i>12.10</i>			
<i>1301742</i>	<i>0.38</i>			
<i>1301942</i>	<i>0.36</i>			
<i>1301992</i>	<i>0.94</i>			
<i>1402032</i>	<i>1.69</i>			
<i>1500090</i>	<i>1.24</i>			

Impairment	WLA t/yr	LA t/yr	MOS t/yr	TMDL t/yr
<i>1501065</i>	<i>24.16</i>			
<i>1501778</i>	<i>72.92</i>			
<i>1501947</i>	<i>3.01</i>			
<i>1600876</i>	<i>18.70</i>			
<i>1601423</i>	<i>10.18</i>			
<i>1601466</i>	<i>50.30</i>			
<i>1601486</i>	<i>54.13</i>			
<i>1601519</i>	<i>7.40</i>			
<i>1601576</i>	<i>64.57</i>			
<i>1601656</i>	<i>3.88</i>			
<i>1601744</i>	<i>54.03</i>			
<i>1700624</i>	<i>1.77</i>			
<i>1701152</i>	<i>0.53</i>			
<i>1701869</i>	<i>2.46</i>			
<i>subtotal</i>	<i>845.18</i>			
<i>Future Growth</i>	<i>6,392.74</i>			

Table 12-5 Maximum Daily Sediment TMDL

Impairment	WLA t/yr	LA t/yr	MOS t/yr	TMDL t/yr
Powell River	8.000	55877.260	52.045	520.452
<i>DEQ VPDES permits:</i>				
VAG750004	0.001			
VAG750024	0.001			
VA0020940	0.227			
VA0029599	0.068			
VA0052311	0.006			
VA0052337	0.006			
VA0053023	0.015			
VA0060798	0.001			
VA0063941	0.001			
VA0070751	0.039			
VA0075515	0.003			
VA0089397	0.091			
VAG110005	0.000			
VAG110210	0.000			
VAR050060	0.000			
VAR050065	0.000			
VAR050067	0.000			
VAR050131	0.000			
VAR050157	0.000			
VAR051276	0.000			
VAR051779	0.000			
VAG840005	0.000			
VAG840005	0.000			
VAG840005	0.000			
VAG840015	0.000			
VAR103405	0.004			
VAR101845	0.002			
VAR101845	0.002			
VAR101845	0.002			
VAR101845	0.002			
VAR104287	0.002			
VAR104305	0.002			
VAR104475	0.002			
VAR102769	0.002			
VAR104500	0.002			

Impairment	WLA t/yr	LA t/yr	MOS t/yr	TMDL t/yr
VAR104502	0.002			
<i>subtotal</i>	0.483			
DMME Mining				
Permits:				
1100033	0.113			
1100439	0.027			
1100583	0.018			
1100584	0.002			
1100735	0.010			
1100877	0.021			
1101350	0.041			
1101554	0.008			
1101565	0.010			
1101661	0.050			
1101760	0.208			
1101800	0.025			
1101804	0.115			
1101813	0.040			
1101824	0.012			
1101905	0.112			
1101918	0.067			
1101954	0.161			
1101975	0.041			
1101991	0.043			
1102011	0.045			
1102028	0.049			
1102031	0.008			
1201589	0.002			
1201680	0.000			
1201803	0.002			
1201875	0.003			
1201921	0.002			
1201949	0.003			
1202015	0.001			
1301430	0.001			
1301533	0.008			
1301561	0.007			
1301590	0.003			
1301687	0.033			

Impairment	WLA t/yr	LA t/yr	MOS t/yr	TMDL t/yr
<i>1301742</i>	<i>0.001</i>			
<i>1301942</i>	<i>0.001</i>			
<i>1301992</i>	<i>0.003</i>			
<i>1402032</i>	<i>0.005</i>			
<i>1500090</i>	<i>0.003</i>			
<i>1501065</i>	<i>0.066</i>			
<i>1501778</i>	<i>0.200</i>			
<i>1501947</i>	<i>0.008</i>			
<i>1600876</i>	<i>0.051</i>			
<i>1601423</i>	<i>0.028</i>			
<i>1601466</i>	<i>0.138</i>			
<i>1601486</i>	<i>0.148</i>			
<i>1601519</i>	<i>0.020</i>			
<i>1601576</i>	<i>0.177</i>			
<i>1601656</i>	<i>0.011</i>			
<i>1601744</i>	<i>0.148</i>			
<i>1700624</i>	<i>0.005</i>			
<i>1701152</i>	<i>0.001</i>			
<i>1701869</i>	<i>0.007</i>			
<i>subtotal</i>	<i>2.312</i>			
<i>Future Growth</i>	<i>5.205</i>			

Table 3 – Nested Segments Biological Monitoring Scores

Station ID	Stream Name	Assessment Unit ID	Date Sample Taken	Virginia Stream Condition Index Score (VSCI)
6BPIG003.55	Pigeon Creek	VAS-P17R_PIG01B12	11/15/2010	32.36
6BPIG005.20	Pigeon Creek	VAS-P17R_PIG01B12	11/15/2010	53.18

Table 4 – Benthic Metrics

Station ID	6BPIG003.55	6BPIG005.20
Metric	11/15/2010	11/15/2010
Richness Score	36.36	54.55
EPT Score	9.09	54.55
% Ephem Score	0.00	7.42
% P+T-H Score	0.00	100.00
% Scraper Score	0.91	0.91
% Chironomidae Score	25.45	12.73
% 2 Dom. Score	31.53	51.23
% MFBI Score	62.57	89.97

Table 5 – Habitat Evaluation for Pigeon Creek

Habitat Metrics			
	Station ID	6BPIG003.55	6BPIG005.20
	Collection Date	11/15/2010	11/15/2010
Channel Alteration	ALTER	19	19
Bank Stability	BANKS	10	7
Bank Vegetation	BANKVEG	16	13
Embeddedness	EMBED	13	10
Channel Flow Status	FLOW	16	8
Frequency of Riffles	RIFFLES	17	17
Riparian Vegetation	RIPVEG	17	10
Sediment Deposition	SEDIMENT	15	10
Substrate Availability	SUBSTRATE	18	17
Velocity/Depth Regime	VELOCITY	10	9
10-Metric Total		151	120



Habitat metric score assessed as “suboptimal”


 Habitat metric score assessed as “marginal” or “poor”

Figure 4 – Field Temperature

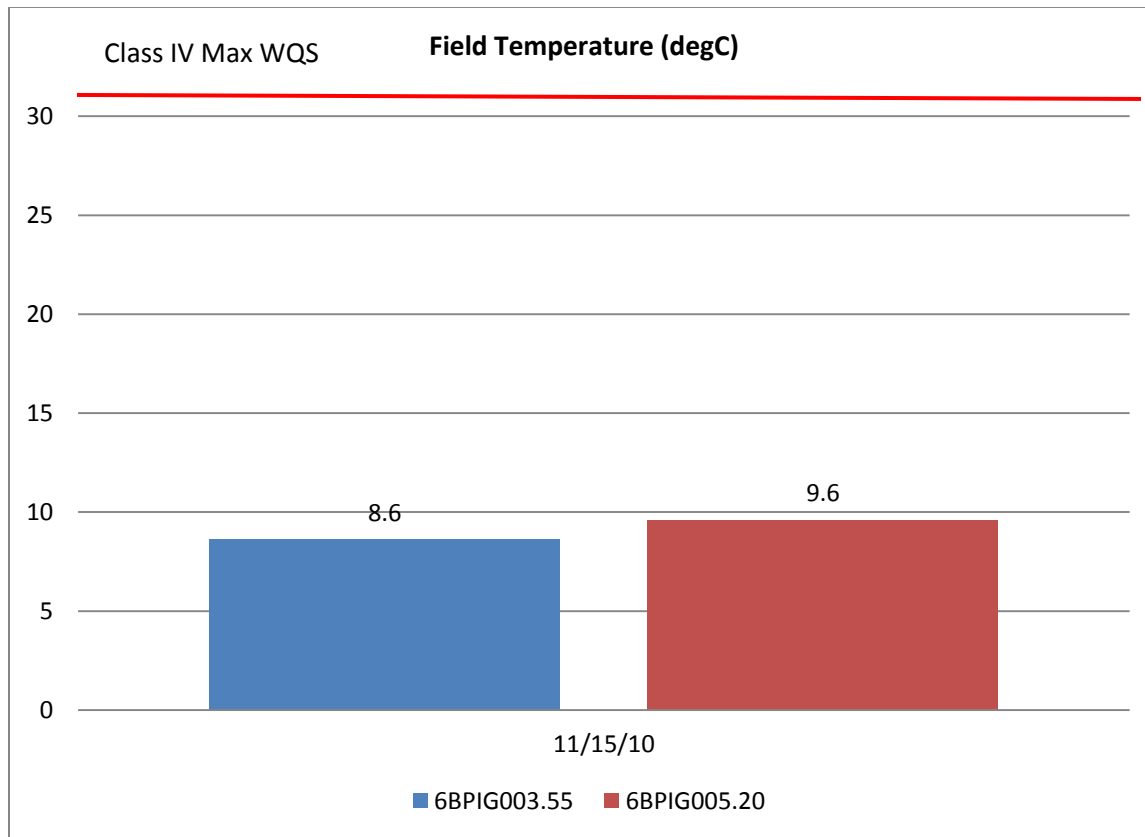


Figure 5 – Field pH

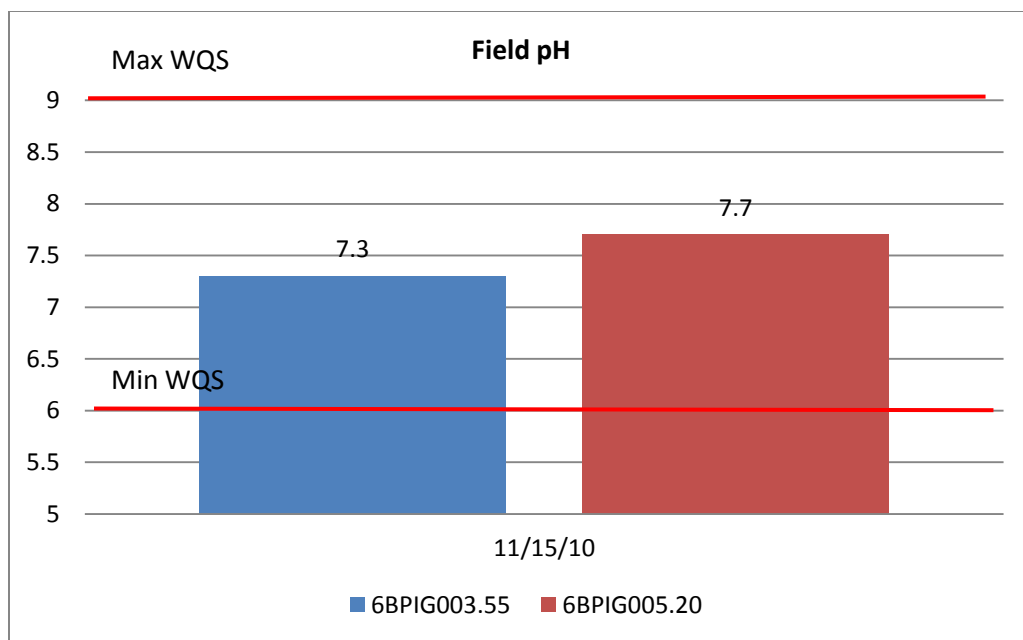


Figure 6 – Field DO

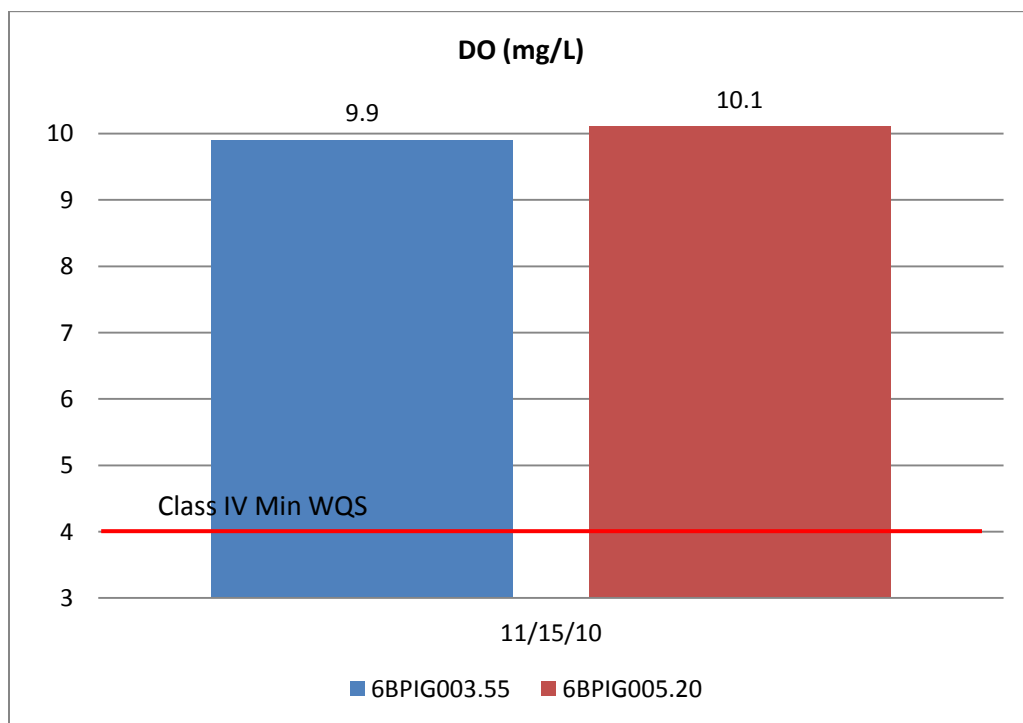
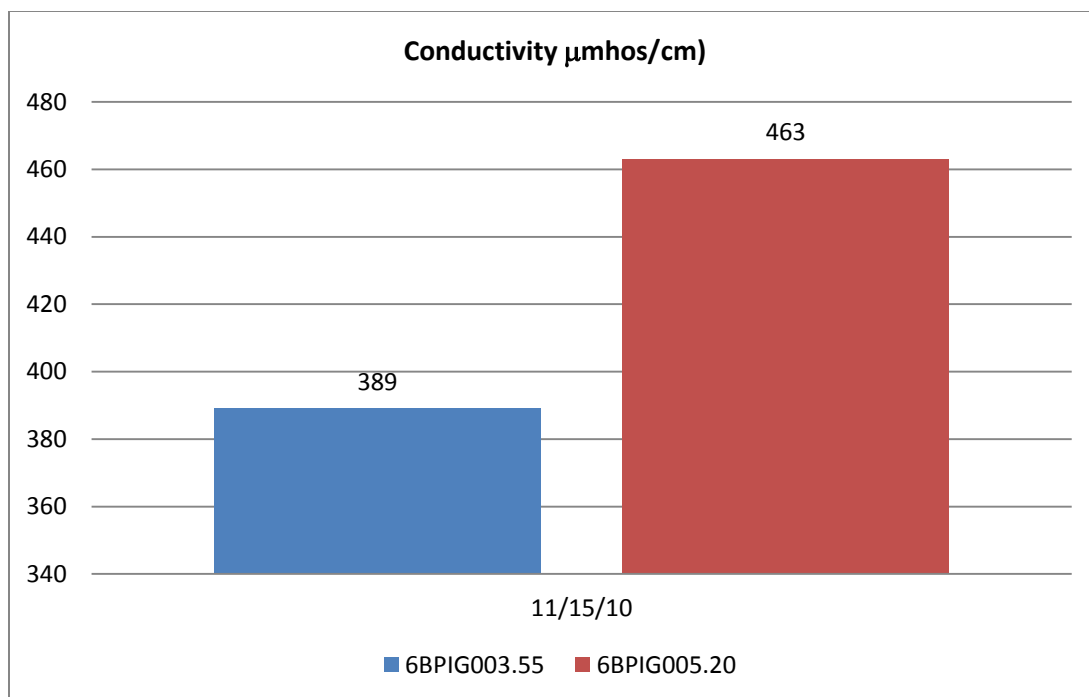


Figure 7 – Field Conductivity



The Stressor Analysis Report developed for the Powell River Phased TMDLs lists the most probable stressor for the Powell River as sediment. Candidate stressors considered in the stressor analysis include pesticides, sulfate, organic matter, conductivity/total dissolved solids, toxics and sediment. A review of the available water quality data for the proposed nested segment indicates that field parameters are within expected ranges. Conductivity is elevated but is lower than levels at the time of TMDL development.

Sediment is supported as a probable stressor for these segments due to the suboptimal and marginal habitat metrics related to sediment. Marginal bank stability along with the presence of fine sediments indicates sediment deposition. The impairment is relatively minor and sediment related habitat metrics are in the middle range, sediment seems to be the most plausible cause of stress to the benthic community in Pigeon Creek.

The impairment on Pigeon Creek can be fully addressed through implementation of the Powell River and Tributaries TMDL.

Based on the rationale listed above, it is our recommendation that the above mentioned assessment unit be placed in Category 4A for the Aquatic Life Use.

Comments from Pauline Adams, US Forest Service

Hello Sandra,

I'm trying to find out more detailed information about the 303d listing of this river segment:

VAV-B42R_NFS01A00

North Fork Shenandoah River

IMP_CAUSE SOURCE CATEGORY AQU_LIFE

Benthic-Macroinvertebrate Bioassessments Non-Point Source 5A Not Supporting

It relates to a potential project on National Forest lands near Bergton, VA.

Wasn't sure who is the best contact, so please forward as needed. However, your name and phone was listed on the VDEQ website for questions about the assessment.

I'm relatively new to my position and VDEQ regulations – so having a hard time locating the specific benthic listing criteria from the web page, and also interested in the raw data.

I see there is a low priority for TMDL, but since it's been listed since 2010 and continues to show up in 2016, figured there would be more information that I could follow up on.

Anything you can share would be greatly appreciated.

Thank you,

Pauline Adams
Forest Hydrologist
Forest Service

DEQ Response to Ms. Adams

The assessment unit that is referenced is described as the “North Fork Shenandoah River from its confluence with the German River downstream to its confluence with Capon Run”. The actual monitoring station is 1BNFS107.86 and is located upstream of Blue Hole. Biological monitoring of streams and rivers using benthic macroinvertebrates is an integral component of the water quality monitoring program in Virginia. These surveys are used to determine if the waterbodies meet their designated aquatic life uses. This assessment unit is listed as impaired for aquatic life based on the Virginia Stream Condition Index (VSCI) which is a multi-metric macroinvertebrate index for Virginia. This index contains eight core metrics that when calculated into one number is known as the Virginia Stream Condition Index. A score of 60 or above is considered to represent a healthy benthic community and fully support aquatic life uses. A score below this level is considered impaired. A stream can be listed as impaired for benthics and aquatic life based on one survey due to the multi-metric nature of the VSCI, however a stream must have two surveys above 60 in two different seasons to be de-listed, thus the de-listing threshold is much higher. The VSCI scores for the data are as follows:

Spring 2008	41.5
Fall 2008	60.2
Spring 2010	59.5
Fall 2010	73.5
Spring 2011	60
Fall 2011	74.4
Fall 2012	74.2

The fall scores appear to be good and the spring scores are not that far off, however, the regional biologist look at the data closely to make a final determination if a station should be de-listed.

Comments from Sandra Stuart

Hello, Sandra.

Why are Lake Merriweather (11,200 acres) and Moores Creek (Lexington) reservoir (1,200 acres) in Rockbridge County not included in the Significant lakes/reservoirs, appendix 7?

thanks,

Sandra Stuart

DEQ Response to Ms. Stuart

Significant Lakes are defined in our assessment guidance as: “A significant lake/reservoir is defined as: a publicly accessible lake/reservoir that is a public water supply and/or 100 acres or more in size and is included in Section 187 list of reservoirs with nutrient criteria”. Publicly accessible means direct access to the water from public property during normal work hours.

Lake Merriweather being privately owned and operated is not a public water supply or publicly accessible even though it meets the size requirement of 100 acres. The Lexington Reservoir while a public water supply (not in use) and over 100 acres is not publicly accessible. As you know, the VRO DEQ staff have monitored the Lexington Reservoir as a citizen monitoring request several years ago and those use determinations are in the 2016 Integrated Report. The lake is currently considered impaired due to pH violations and DO is considered impaired due to natural conditions. DEQ was able to monitor the Lexington Reservoir as guidance allows regional discretion to monitor lakes not on the significant lakes list if a lake meets one of the significant lake criteria and is of concern to the region.

Comments from Newport News Waterworks Department

Ms. Mueller-

We have some questions regarding the impairment listing for Lee Hall Reservoir in Newport News in the 2016 draft water quality assessment. The fact sheets are very helpful, but lack some key details that can help us understand and deal with the issue(s).

Specifically we are investigating the Fish Consumption impairment for Mercury and PCB's. Your webpage did describe the general details of Tier 1 sampling, but we need details regarding the measured levels and standards used for the Lee Hall Reservoir location. I also noted in the Tier 1 sampling program that sediment samples are typically taken with fish tissue to help determine impairment status and if Tier 2 sampling is needed. We would also like to review the sediment data for this location if available.

I'm sure we will have additional questions once we get these data and a better understanding of the assessment details for this reservoir. Any assistance you can provide is appreciated.

Thanks,

Ron Harris, PG
Chief of Water Resources
Acting Natural Resources Division Manager

DEQ Response to Newport News Waterworks Department

Lee Hall Reservoir is impaired for Fish Consumption Use in the 2016 draft IR based on an assessment performed in the 2010 Integrated Report cycle with fish tissue data collected in 2005 from station 2WWK011.48. The Fish Consumption Use impairment was based on As, Hg and PCB from fish tissue. The Fish Consumption Use is assessed based on a comparison of fish tissue data to the water quality standard criterion-based tissue values and tissue screening values for toxic pollutants. Two or more exceedances of Tissue Values results in an impaired assessment of the water for the fish consumption designated use.

DEQ 2005 Fish metals results

WBID	VIMS ID	DEQ site #	Station name/location/description	DEQ river/mile	Sampling Date	Species id	Fish species name	No. of fish analyzed	Length (cm)	Weight (g)	Latitude (deg dec_)	Longitude (deg dec_min)	Water %	Lipid %	Analyte -> Sample	ppm ¹ (wet weight basis)					
																As	Cd	Cr	Hg	Pb	Se

DEQ SCREENING VALUES (ppm)															>>>>>			>>>>>>>			>>>>>>>													0.072	11	32	0.3/0.5	NA	54
G11L	5TF044	89	Newport News Reservoir at Rt. 2	C2WWK011.48	7/18/2005	SFBG	Bluegill Sunfish	10	14.8	-	14.60	-	12	N37° 10.30	W76° 33.728'	81.52	3.15	5TF044	<0.05	<0.01	<0.05	0.03	<0.1	<0.5															
G11L	5MF046	89	Newport News Reservoir at Rt. 2	C2WWK011.48	7/18/2005	BSLM - Rep 1	Largemouth Bass #1 - 1	1	52.1	2182	N37° 10.30	W76° 33.728'			5MF046	<0.05	<0.01	0.24	0.34	0.15	<0.5																		
G11L	5MF047	89	Newport News Reservoir at Rt. 2	C2WWK011.48	7/18/2005	BSLM - Rep 2	Largemouth Bass #6 - 2	1	51.8	2203	N37° 10.30	W76° 33.728'			5MF047	<0.05	<0.01	0.17	0.65	<0.1	<0.5																		
G11L	5MF048	89	Newport News Reservoir at Rt. 2	C2WWK011.48	7/18/2005	BSLM - Rep 3	Largemouth Bass #4 - 3	1	49.3	1929	N37° 10.30	W76° 33.728'			5MF048	0.32	<0.01	0.26	0.18	<0.1	<0.5																		
G11L	5TF043	89	Newport News Reservoir at Rt. 2	C2WWK011.48	7/18/2005	BSLM - Rep 4	Largemouth Bass - 4	3	43.1	-	4	1340 - 144	N37° 10.30	W76° 33.728'	77.57	5.58	5TF043	<0.05	<0.01	0.21	0.18	<0.1	<0.5																
G11L	5MF049	89	Newport News Reservoir at Rt. 2	C2WWK011.48	7/18/2005	PCYW	Yellow Perch #1	1	26.1	332	N37° 10.30	W76° 33.728'			5MF049	<0.05		0.01	0.28	0.12	<0.1	<0.5																	
G11L	5PF169	89	Newport News Reservoir at Rt. 2	C2WWK011.48	7/18/2005	CARP - Rep 1	Carp #3 - 1	1	80.0	6500	N37° 10.30	W76° 33.728'																											
G11L	5PF170	89	Newport News Reservoir at Rt. 2	C2WWK011.48	7/18/2005	CARP - Rep 2	Carp #1 - 2	1	78.6	6750	N37° 10.30	W76° 33.728'																											
G11L	5PF171	89	Newport News Reservoir at Rt. 2	C2WWK011.48	7/18/2005	CARP - Rep 3	Carp #2 - 3	1	73.1	5500	N37° 10.30	W76° 33.728'																											
G11L	5PF172	89	Newport News Reservoir at Rt. 2	C2WWK011.48	7/18/2005	CARP - Rep 4	Carp #4 - 4	1	72.8	5500	N37° 10.30	W76° 33.728'																											

NOTES:

blue font indicates analyte concentration greater than or equal to DEQ's screening value

red font indicates analyte concentration greater than or equal to VDH level of concern

yellow highlighted record indicates Lead (Pb) concentration above detection limit

DEQ 2005 Fish PCBs results

															ppb ¹ (wet wt)
WBID	VIMS ID	DEQ site #	Station name/location/description	DEQ rivermile	Sampling Date	Species id	Fish species	No. of fish analyzed	Length (cm)	Weight (g)	Latitude (deg dec. m)	Longitude (deg dec. m)	Water %	Lipid %	Total PCB ²
DEQ SCREENING VALUES (ppb)															50/54/500
G11E	5PF169	89	Newport News Reservoir at Rt. 105 bridge (Warwick Co)	2CWWK011.48	7/18/2005	CARP - Rep 1	Carp #3 - 1	1	80.0	6500	N37° 10.3'	W76° 33.7'	77.24	11.69	19.49
G11L	5FP170	89	Newport News Reservoir near Rt. 105 bridge (Warwick Co)	2CWWK011.48	7/18/2005	CARP - Rep 2	Carp #1 - 2	1	78.6	6750	N37° 10.3'	W76° 33.7'	69.33	34.84	65.94
G11E	5PF171	89	Newport News Reservoir at Rt. 105 bridge (Warwick Co)	2-WWK011.48	7/18/2005	CARP - Rep 3	Carp #2 - 3	1	73.1	5500	N37° 10.3'	W76° 33.7'	77.30	16.19	26.08
G11E	5PF172	89	Newport News Reservoir at Rt. 105 bridge (Warwick Co)	2-WWK011.48	7/18/2005	CARP - Rep 4	Carp #4 - 4	1	72.8	5500	N37° 10.3'	W76° 33.7'	79.02	4.60	24.17

In 2016 IR the PCB value is 20 ppb

NOTES:

green font indicates analyte concentration greater than or equal to VDH "lower" level of concern of 50 ppb
 ##### blue font indicates analyte concentration greater than or equal to DEQ's screening value of 54 ppb
 ##### red font indicates analyte concentration greater than or equal to VDH "upper" level of concern of 500 ppb

DEQ 2005 **DEQ 2005 Sediment Metals results**

									%	ppm ¹ (dry weight basis)																		
WBID	DEQ site #	Sampling Date	DEQ rivermile	Stream name/lo	Latitude	Longitude	% TOC ²	Analyte ³	Al	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	Zn							
								Sample																				
NOAA's Effects Range-Median							ER-M	>>>>>	**	3.7	70	9.6	370	270	0.71	51.6	218	**	**	**	410							
NOAA's Effects Range-Low							ER-L	>>>>>	**	1	8.2	1.2	81	34	0.15	20.9	46.7	**	**	**	150							
Freshwater Consensus-Based ProbaPEC									NA												33	4.98	111	149	1.06	48.6	128	459
G08L	74	6/30/2005	2CLTL001	Little Creek Rese	N37° 21.0	W76° 50.4	1.00	74-5TS018	0.51	<0.02	1.5	<0.01	10.2	3.5	0.01	11.2	7.6	<0.5	<0.5	<0.3	8.8							

DEQ 2005 Sediment PCBs results

									ppb ¹ (dry weight basis)
WBID	DEQ	Sampling	DEQ	Stream name/lo	Latitude	Longitude	% TOC ²	Analyte ³	Total
	site #	Date	rivermile					Sample	
NOAA's Effects Range-Median					ER-M	>>>>			180
NOAA's Effects Range-Low					ER-L	>>>>			22.7
Freshwater Consensus-Based Proba PEC									676
G11L	89	7/18/2005	2CWWK0	Newport News R	N37° 10.3	W76° 33.7	3.46	5TS023	34.57

APPENDIX E-1

FISH TISSUE VALUES (TV)*		NON CARCINOGEN	CARCINOGEN
		CRITERION BASED TISSUE VALUE (TV)	CRITERION BASED TISSUE VALUE (TV)
COMPOUND	CAS #	PPB (wet-weight)	PPB (wet-weight)
Acenaphthene	83-32-9	240,000.00	
Acrolein	107-02-8	2,000.00	
Acrylonitrile	107-13-1		74
Aldrin	309-00-2		2.40
Anthracene	120-12-7	12,000,000	
Antimony	7440-36-0	1,600	
Benzene	71-43-2		2,700
Benzidine	92-87-5		0.17
Benzo(a)anthracene	56-55-3		5.50
Benzo(b)fluoranthene	205-99-2		5.50
Benzo(k)fluoranthene	207-08-9		5.50
Benzo(a)pyrene	50-32-8		5.50
Bis2-chloroethyl ether	111-44-4		36
Bis2- chloroisopropyl ether	108-60-1	160,000	
Bis2- ethylhexyl Phthalate	117-81-7	2,900	
Bromoform	75-25-2		5,100
Butyl benzyl phthalate	85-68-7	800,000	
Carbon tetrachloride	56-23-5		310
Total Chlordane	57-74-9		110
Chlorobenzene	108-90-7	16,000	
Chlorodibromomethane	124-48-1		480
2-Chloronaphthalene	91-58-7	320,000	
Chloroform	67-66-3		40,000
2-Chlorophenol	95-57-8	20,000	
Chrysene	218-01-9		5.50
Cyanide	57-12-5	80,000	
DDD	72-54-8		170
DDE	72-55-9		120
Total DDT	50-29-3		120
Dibenz(a,h)anthracene	53-70-3		5.50
1,2-Dichlorobenzene	95-50-1	72,000	
1,3-Dichlorobenzene	541-73-1	54,000	
1,4-Dichlorobenzene	106-46-7	11,000	
3,3-Dichlorobenzidine	91-94-1		89
Dichlorobromomethane	75-27-4		650
1,2-Dichloroethane	107-06-2		440
1,1-Dichloroethylene	75-35-4	40,000	
1,2-Trans-dichloroethylene	156-60-5	16,000	
2,4-Dichlorophenol	120-83-2	12,000	
1,2-Dichloropropane	78-87-5		600

1,3-Dichloropropene	542-75-6	400	
Dieldrin	60-57-1		2.50
Diethyl phthalate	84-66-2	3,200,000	
2,4-Dimethylphenol	105-67-9	80,000	
Dimethyl Phthalate	131-11-3	40,000,000	
Di-n-butyl phthalate	84-74-2	400,000	
2,4-Dinitrophenol	51-28-5	8,000	
2-Methyl-4,6-dinitrophenol	534-52-1	1,600	
2,4-Dinitrotoluene	121-14-2		130
Dioxin	1746-01-6		0.00026
1,2-Diphenylhydrazine	122-66-7		50
Endosulfan (I and II)	115-29-7	24,000	
Endosulfan sulphate	1031-79-8	24,000	
Endrin	72-20-8	240	
Endrin aldehyde	7421-93-4	1,200	
Ethylbenzene	100-41-4	80,000	
Fluoranthene	206-44-0	160,000	
Fluorene	86-73-7	160,000	
Heptachlor	76-44-8		8.90
Heptachlor epoxide	1024-57-3		4.40
Hexachlorobenzene	118-74-1		25
Hexachlorobutadiene	87-68-3		510
Hexachlorocyclohexane (alpha-BHC)	319-84-6		6.30
Hexachlorocyclohexane (beta -BHC)	319-85-7		22
Hexachlorocyclohexane (gamma-BHC) (lindane)	58-89-9		240
Hexachlorocyclopentadiene	77-47-4	4,800	
Hexachloroethane	67-72-1		2,900
Indeno(1,2,3-cd)pyrene	193-39-5		5.5
Isophrone	78-59-1		42,000
Mercury (Methyl) **	22967-92-6	300	
Methyl Bromide	74-83-9	5,600	
Methylene Chloride	75-09-2		5,300
Nickel	744-00-2	220,000	
Nitrobenzene	98-95-3	2,000	
N-nitrosodimethylamine	62-75-9		0.78
N-nitrosodiphenylamine	86-30-6		8,200
N-nitrosodi-n-propylamine	621-64-7		5.70
PCB Total/congeners	1336-36-3		20
Pentachlorophenol	87-86-5		330
Phenol	108-95-2	1,200,000	
Pyrene	129-00-0	120,000	
Selenium	7782-49-2	20,000	
1,1,2,2-Tetrachloroethane	79-34-5		200
Tetrachloroethylene	127-18-4		1,000
Thalium	7440-28-0	54	
Toluene	108-88-3	64,000	
Toxaphene	8001-35-2		36
1,2,4-Trichlorobenzene	120-82-1	8,000	
1,1,2-Trichloroethane	79-00-5		700

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Appendix E-1

Trichloroethylene	79-01-6		3,200
2,4,6-Trichlorophenol	88-06-2		3,600
Vinyl Chloride	75-01-4		29
Zinc	7440-66-6		1,200,000

*These fish tissue values have been calculated based on the Water Quality Standards that are associated with the latest Triennial Review criteria proposals as adopted by the State Water Control Board in October 2008.

**The fish tissue criterion for methylmercury applies to fish species commonly eaten in the local waterbody and applies to most fish species in the DEQ database except bowfin or longnose gar because fish consumption surveys show that these species are rarely consumed in Virginia. Total mercury concentrations in fish tissue are assumed to equal methylmercury concentrations.

APPENDIX E-2

RISK-BASED TISSUE SCREENING VALUE (TSVs) FOR FISH TISSUE UPDATED FROM INTEGRATED RISK INFORMATION SYSTEM (IRIS) FOR GENERAL POPULATION (ADULT)

BODY WEIGHT (KG) 70
 RISK LEVEL 10^{-5}
 CONSUMPTION RATE (KG/DAY) 0.0175

Fish Tissue Screening Values (TSV)		NON CARCINOGEN TISSUE SCREENING VALUE (TSV)	CARCINOGEN TISSUE SCREENING VALUE (TSV)
COMPOUND	CAS #	PPB (wet-weight)	PPB (wet-weight)
Arsenic (inorganic)	7440-38-2		270*
Barium	7440-39-3	800,000	
BHC isomers	608-93-1		0
Brominated Diphenyl ethers (BDEs)			5000 (VDH)**
Cadmium	7440-43-9	4,000	
Decabromdiphenyl ether	1163-19-5		28,000
Hexabromodiphenyl ether	36483-60-0		800
Pentabromodiphenyl ether	32534-81-9		8,000
Chromium III	16065-83-1	6,000,000	
Chromium VI	18540-29-9	12,000	
Chlorpyrifos	2921-88-2	12,000	
Diazinon	333-41-5	3600	
Disulfoton	298-04-4	160	
Ethion	563-12-2	2,000	
Kepone	143-50-0		300 (VDH)**
Methoxychlor	72-43-5	20,000	
Mirex	2385-85-5	8,000	
Oxyfluorfen	42874-03-3	12,000	
PAHs (sum PEC) ***			15
Terbufos	13071-79-9	100	
Tributyltin	56-35-9	1,200	

*The screening value for arsenic applies to inorganic arsenic only. Organic forms of arsenic are not carcinogenic and are relatively nontoxic. There is a general consensus that 85 to 90% of arsenic found in fish tissue is organic arsenic. The screening value of 270 ug/kg total arsenic is based on the estimate that 10% of total arsenic detected in fish tissue is inorganic arsenic.

** These values are based on recent changes to the toxicological data used to calculate the screening values, or recent recommendations from U.S. EPA or the Virginia Department of Health. These screening values are not based on the same toxicological data that were used to develop the existing water quality criteria.

*** Mixtures of seven polynuclear aromatic hydrocarbons (PAHs) that are classed as probable human carcinogens were assessed based on a screening value concentration of 15 ppb calculated as a sum potency equivalency concentration (PEC) using methods described in EPA's Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Vol. 1, (EPA 823-R-95-007) and Vol. 2 (EPA 823 B-00-008) using the following equation;

$$PEC = \sum_i (RP_i \times C_i)$$

where; RP_i = relative potency for the i th PAH
 C_i = concentration of the i th PAH in fish tissue)

The relative potency estimates used for these PAHs were:

Benzo(a)pyrene	1.0
Benzo(a)anthracene	0.145
Benzo(b) fluoranthene	0.167
Benzo(k)fluoranthene	0.020
Chrysene	0.0044
Dibenz(a,h)anthracene	1.11
Indeno(1,2,3-cd)pyrene	0.055

APPENDIX F

Freshwater Consensus- Based Sediment Screening Values (SVs)

Analyte (Metals)	Consensus PEC (ppm) dry weight
Arsenic	33
Cadmium	4.98
Chromium	111
Copper	149
Lead	128
Mercury	1.06
Nickel	48.6
Silver	NA
Zinc	459
Analyte (Organics/Pesticides)	Consensus PEC (ppb) dry weight
Acenaphthene	NA
Acenaphthylene	NA
Anthracene	845
Benzo-a-pyrene	1,450
Benz(a)Anthracene	1,050
Chrysene	1,290
Dibenz[a,h]Anthracene	NA
Fluoranthene	2230
Fluorene	536
Methylnaphthalene, 2-	NA
Naphthalene	561
Phenanthrene	1,170
Pyrene	1,520
LMW PAHs	NA
HMW PAHs	NA
Total PAHs ** (see footnote)	22,800
Chlordane	17.6
DDD	28
DDE	31.3
DDT	62.9
DDT, total	572
Dieldrin	61.8
Total PCBs	676
Endrin	207
Heptachlor Epoxide	16
Lindane	4.99
NA = Not Available	

Estuarine NOAA-based ER-M Sediment Screening Values (SVs)

Trace Elements (Metals)	ER-M Value ppm (dry weight)
Antimony (Sb)	NA
Arsenic (As)	70
Beryllium	NA
Cadmium (Cd)	9.6
Chromium (Cr)	370
Copper (Cu)	270
Lead (Pb)	218
Manganese (Mn)	NA
Mercury (Hg)	0.71
Nickel (Ni)	51.6
Selenium (Se)	NA
Silver (Ag)	3.7
Thallium	NA
Zinc (Zn)	410

Pesticides and Other Organic Substances –parts per billion dry weight

CAS #	Substance	ER-M Value(dry weight) (ppb)
336363	Polychlorinated Biphenyls (PCBs)	180
309002	Aldrin	NA
57749	Chlordane	6
NA	total DDT (include metabolites)	46.1
72548	DDD	20
50293	DDT	7
72559	DDE	27
60571	Dieldrin (EPA proposed criteria)	8
72208	Endrin	NA
76448	Heptachlor	NA
1024573	Heptachlor epoxide	NA
118741	Hexachlorobenzene	NA
608731	Hexachlorocyclohexane	NA
58899	Lindane	NA
2385855	Mirex	NA
108952	Phenol	NA
117817	Di (2-Ethylhexyl) Phthalate	NA
84742	N-Butyl Phthalate	NA
83329	Acenaphthene	500 LMW PAH
208968	Acenaphthylene	640 LMW PAH
120127	Anthracene	1100 LMW PAH
50328	Benzo-A-Pyrene	1600 HMW PAH
191242	Benzo [GHI] Perylene	NA HMW PAH
56553	Benz[A] Anthracene	1600 HMW PAH
218019	Chrysene	2800 HMW PAH
53703	Dibenz [A,H] Anthracene	260 HMW PAH
206440	Fluoranthene	5100 HMW PAH
86737	Fluorene	540 LMW PAH
193395	Indeno (1,2,3-CD)Pyrene	NA HMW PAH

91576	Methylnaphthalene, 2	670	LMW PAH
91203	Naphthalene	2100	LMW PAH
85018	Phenanthrene	1500	LMW PAH
129000	Pyrene	2600	HMW PAH
NA	Low Molecular Weight (LMW)PAHs	3160	
NA	High Molecular Weight (HMW) PAHs	600	
NA	Total PAHs **(see footnote)	44,792	

*Changes or updates to any of the ER-M or PEC screening values should be updated in the assessment spreadsheet used to calculate the estuarine weight of evidence.

**sum of 24 Polyaromatic hydrocarbons used in previous reports, also polynuclear aromatic hydrocarbons (PNAs)

DEQ acknowledges the use of the ER-M or PEC may be limited (for several reasons) in their ability to accurately predict biological effects. Given that DEQ continues to employ the collection of bulk sediment with chemical analysis as a cost-effective way to monitor a great number of sediment sites, these thresholds are an appropriate tool for assessing sediment data relative to its potential harm to aquatic life.

Citation:

Freshwater PECs: MacDonald, D.D., C.G. Ingersoll, T.A. Berger. 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. *Arch. Environ. Contam. Toxicol.* 39:20-31.

Estuarine ER-Ms: Buchanan, M.F. 1999 National Oceanic and Atmospheric Administration *Screening Quick Reference Tables*, NOAA HAZMAT Report 99-1 Seattle, WA, Hazardous Materials Response and Assessment Division, 12 pages.

Comments from Jim Echols, VA Department of Conservation & Recreation

Ms. Mueller,

I glanced at the draft 2016 Water Quality Integrated Report today. On page 168 the report talks about fencing livestock out of streams. However, the report specifically said that “cattle” are fenced out. I suggest changing this to “livestock” because this more accurately reflects what is being done. Certainly cattle are the most numerous and first animal we think of when fencing livestock out of streams, but other livestock is also being excluded from streams.

Thank you!

Jim Echols
Western Area Manager
Division of Soil and Water Conservation
Department of Conservation & Recreation

DEQ Response to Jim Echols, VA Department of Conservation & Recreation

Thank you for your review and feedback on the 2016 Water Quality Integrated Report. We have updated the reference to “cattle” on Page 168 to “livestock” to more accurately portray the activities that are taking place in the Commonwealth.

Comments from Hampton Roads Sanitation District



September 6, 2017

Ms. Sandra Mueller
Virginia Department of Environmental Quality
Office of Water Monitoring and Assessment
P.O. Box 1105
Richmond, VA 23218-1105

Re: Draft 2016 Water Quality Assessment Integrated Report

Dear Ms. Mueller,

Hampton Roads Sanitation District (HRSD), a regional wastewater treatment entity serving 18 counties and cities in southeastern Virginia, is pleased to offer the following comments concerning the Virginia Department of Environmental Qualities draft 2016 305(b)/303(d) Water Quality Assessment Integrated Report.

HRSD is supportive of the efforts VA DEQ has taken in producing the above referenced report. These efforts continue to allow focused efforts in improving the overall aquatic environmental quality in Virginia.

Comment 1: "5R" TMDL alternative category designation.

HRSD is supportive of VA DEQ's effort in developing TMDL alternatives for specific water segment impairments. Specifically the "5R" designation for water areas that fail to meet specific water quality standards but for which EPA approved restoration plans will result in future attainment goals. The "5R" designation captures the lack of attainment of specific water quality standards but allows for an alternative approach in meeting those standards. These alternative approaches are more beneficial from a resource perspective and allow for an accepted plan for attaining desired environmental compliance.

It is HRSD's standing that for a program such as Virginia 303(d) impaired waters program, alternative approaches should be taken that allow for the conservation of limited resources. This alternative designation may also allow for more rapid attainment of environmental standards than the laborious TMDL process.

Comment 2: "3C" water impairment designation as indicated by citizens monitoring groups.

HRSD is supportive of VA DEQ's effort to utilize data from citizens monitoring groups in the assessment of water impairments. The "3C" assessment criteria allows for an avenue whereby citizens monitoring groups data can be used by VA DEQ as an indicator for possible water quality impairments. Individual citizens groups routinely focus on geographically

relevant water segments that may not be sampled at the frequency at which VA DEQ traditionally surveys. The data generated from the increased frequency of sampling by said citizens group may potentially identify a water quality impairment that may otherwise go undetected by VA DEQ.

It should be stated however that though a water segment impairment that falls into the "3C" category is significant it does not warrant a TMDL response. Data generated by citizens groups should only serve as an early indicator that a potential impairment exists. With a "3C" designation VA DEQ would then have reason to devote increased resources towards officially quantifying the suspected water quality impairment. Only officially qualified data should be utilized in the development of any TMDL.

HRSD is supportive of the "3C" designation in that it provides an avenue for citizens groups to become involved in the Virginia water quality assessment process. This in turn provides a small form of transparency in the water quality assessment program.

Conclusion:

Again, HRSD appreciates VA DEQ's efforts on the 2016 Integrated Report, and the ability to comment on its contents. HRSD continues to look forward to working with VA DEQ on this and future Virginia water quality efforts.

Sincerely,



Chris Burbage, PhD
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DEQ Response to Hampton Roads Sanitation District

“5R” TMDL Alternative category designation

EPA’s 2016 IR Guidance acknowledges that restoration plans that serve as alternatives to TMDLs may be the best option to reach water quality standards faster. However, when the TMDL alternative lacks enforceable “other pollution control requirements,” the water cannot be assessed as 4B, and must remain in category 5. In EPA’s 2016 IR Guidance the national subcategory of 5-alternative is discussed and introduced. In Virginia this is the state subcategory 5R (detailed description below).

EPA specifically recommends that the 5R documentation describe the following six minimum elements:

- a) The identification of the point and nonpoint sources.* For point sources, an analysis should be included to document whether they are causing or contributing to the water quality impairments. If it is determined that the point sources are causing or contributing, then a Water Quality Based Effluent Limitation (WQBEL) or Best Management Practices Approach² should be developed and implemented through NPDES permits.
- b) The point source and nonpoint source water quality restoration activities that are expected to result in water quality improvements and restoration.* Where applicable, describe any authorities that may require water quality controls to be implemented (e.g., state or local regulations, permits, contracts and grant/funding agreements).
- c) Cost estimates and funding commitments to implement the water quality restoration activities.* In order to provide assurance that water quality restoration can occur through the implementation of water quality restoration activities, cost estimates and secured funding sources that will be used to implement these activities should be identified.
- d) An anticipated schedule for implementing the water quality restoration activities, including the anticipated completion date and the estimated pollutant load reductions necessary to meet water quality standards.* The schedule should outline specific activities and include a timeline of when each phase will be implemented and accomplished. The schedule can be revised and updated at each 303(d) listing cycle.
- e) A water quality monitoring component to evaluate and track the effectiveness of the scheduled water quality restoration activities at each 303(d) listing cycle.* Baseline water quality conditions should be established in order to accurately measure water quality progress. At each 2-year 303(d) listing cycle, performance measurements, whether environmental, programmatic, or social, should be provided for each implemented water quality restoration activity to measure progress. It is understood that each water restoration activity may not result in improved water quality; however the combined restoration activities should result in improved water quality at each 303(d) listing cycle.

f) An anticipated date for achieving water quality standards. Projects are expected to follow adaptive management allowing critical milestones to be adjusted as project plans and goals may change as implementation occurs. Once water quality standards have been met, the State may determine that the waterbody is appropriate to be included in category 1 or 2. If the project does not meet water quality standards by the estimated completion date, sufficient trends toward improved water quality must be shown in order to continue in the 5R program and an updated implementation schedule including revised critical milestones should be submitted to EPA. The project will continue to be reviewed every 2-year 303(d) listing cycle until water quality standards are met.

“3C” water impairment designation as indicated by citizens monitoring groups

DEQ Assessment Category 3C is defined as data collected by a citizen monitoring or another organization indicating water quality problems may exist but the methodology and/or data quality has not been approved for a determination of support of designated use(s). These waters are considered as having insufficient data with observed effects. Such waters will be prioritized by DEQ for follow up monitoring.

“Data generated by citizens groups should only serve as an early indicator that a potential impairment exists.”

The DEQ Quality Assurance Coordinator works with non-agency groups to collect Level III data, characterized as being approved by DEQ. The group follows DEQ testing protocols and quality assurance. Field sampling and laboratory testing protocols are approved by DEQ or DEQ approved accrediting authority. The group possesses a DEQ approved QAPP and SOP with no deviation from DEQ approved standardized methods (EPA methods, Standard Methods, etc.). Finally, the group must provide calibration and quality control associated information to DEQ when submitting data. This information must meet the specific criteria stated in the QAPP.

DEQ views this level of data as if DEQ had collected and analyzed the sample. Data that meets Level III criteria will be used in the 305(b) water quality assessment and for 303(d) listing/delisting of impaired waters.

For the 2016 assessment report, DEQ received citizen monitoring data from 1,902 sites. 719 sites met Level II (Category 3C/3D), and 916 sites met Level III for at least one water quality parameter. Of these 1,902 Level II and III stations, 128 had either missing sample site coordinates or were located in non-assessable locations such as at permitted wastewater outfalls. This assessment cycle marks the highest ever number of total number of citizen stations sampled and Level III citizen volunteer stations included in a Virginia 305(b)/303(d) Integrated Report.

Comments from Chesapeake Bay Foundation



CHESAPEAKE BAY FOUNDATION
Saving a National Treasure

September 6, 2017

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Sandra Mueller
Virginia Department of Environmental Quality
Office of Water Monitoring and Assessment
P.O. Box 1105
Richmond, VA 23218-1105

Dear Ms. Mueller,

On behalf of the Chesapeake Bay Foundation (CBF), I submit the following comments regarding the 2016 Virginia Water Quality Assessment 305(b)/303(d) Integrated Report. First, I'd like to express our appreciation for the tremendous effort that Virginia Department of Environmental Quality (DEQ) staff and Virginia's citizen monitoring groups have put into monitoring, analyzing, and reporting upon the health of our state's waters. The 2016 report includes assessments of more than 22,000 miles of Virginia streams, which provides critical information for improving water quality.

This report reveals promising findings related to attainment of dissolved oxygen, particularly in the James River, the Rappahannock River and the mainstem Chesapeake Bay. While these are just initial signs of recovery in a fragile system they validate the efforts of the Chesapeake Bay Blueprint. Still, 87% of Virginia's assessed estuaries and over two-thirds of Virginia's assessed streams are still impaired. A significant proportion of Virginia's waters are impaired due to nutrients, sediment, and E. coli directly related to non-point source pollution emphasizing the need for continued implementation from agriculture and stormwater among other sectors.

Concerns regarding Submerged Aquatic Vegetation Criteria and attainability:

The Commonwealth of Virginia has been working to restore Submerged Aquatic Vegetation (SAV) in the Chesapeake Bay and its tidal tributaries for nearly half a century. The state has worked vigorously to eliminate nutrient and sediment pollution which prevent grasses from thriving along with the fisheries which rely upon these habitats. In recent years, water quality analyses, including those referenced in this report, have begun documenting small improvements in SAVs which yield tremendous hope for the future of the Chesapeake Bay¹. While this system is only a shell of the system which once existed, there are still many reasons

¹ Orth, R. J., D. J. Wilcox, J. R. Whiting, A. K. Kenne, L. Nagey, and E. R. Smith. 2016. 2014 Distribution of Submerged Aquatic Vegetation in the Chesapeake Bay and Coastal Bays. VIMS Special Scientific Report Number 156. Final report to EPA, Chesapeake Bay Program, Annapolis, MD. Grant No CB96321901-0,

to believe there is potential for substantial improvements in water quality in the Chesapeake Bay and its major tributaries and thus recovery of Submerged Aquatic Vegetation.

Water Quality Criteria for SAVs associated with five estuarine segments were established based upon attainability and it is unclear there is sufficient recent documentation to defend this designation.

Virginia's goals for SAVs are outlined in many different contexts including Virginia's statutory code, Chesapeake Bay Program Technical Addendums, the Chesapeake Bay TMDL, Chesapeake Bay Agreements and most recently in the 2016 Integrated Report (pg. 147). Consistency among these benchmarks is important for clearly illustrating the goals of the partnership among many diverse stakeholders. Recently, the Chesapeake Bay Program has developed a draft Technical Addendum for *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries*. Previous versions of this technical addendum have been adopted by reference in Virginia's water quality standards. This document outlines historical SAV acreage goals which have been adopted over the past 25 years throughout the Bay watershed. Table V-1 of the addendum documents these results and highlights some important discrepancies between SAV acreage criteria in a few of Virginia's water quality criteria and the SAV levels developed by the Chesapeake Bay Program.

Five segments in Virginia, including the Upper Tidal Fresh James, the Lower Tidal Fresh James, the Mesohaline James, the Polyhaline James and the Mesohaline Rappahannock have substantial discrepancies between the actual mapped SAV acreages and the current water quality standards as defined in Virginia's code (see table 1). Based upon the current draft, the rationale for these discrepancies is either unknown² or based upon some assessment of attainability which was established in 2004³. Further, the discrepancy is significant as described by the Scientific and Technical Advisory Committee for the Chesapeake Bay Program, totaling over 4,000 acres of submerged aquatic vegetation⁴.

² Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries. 2017 Technical Addendum. January 2017 Revised Draft. "WQS Acreage of unknown origin" pg. 56-57.

³ Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries. 2017 Technical Addendum. January 2017 Revised Draft. "derived as 'attainable acres' developed from the May 2004 Chesapeake Bay Program Water Quality/Sediment Transport model confirmation run (Source: Lewis Linker (USEPA) via Cindy Johnson VADEQ)" pg. 56-57.

⁴STAC Criteria Addendum Review: Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries: 2017 Technical Addendum Model attainability issues: "The document states (page 48): "With few exceptions, the jurisdictions' Chesapeake Bay water quality standards segment-specific SAV restoration acreages are equal to or greater than the segment-specific acreage goals supporting the original 185,000 acre goal (Table V-1)." The text should be made clearer that these "few exceptions" are significant. For a number of segments in Virginia, the state's SAV restoration acreages are lower than the CBP water quality specific acreages. These lower restoration goals,

Table 1 Virginia Water Quality Standards (WQS) for Submerged Aquatic Vegetation (acres) and Chesapeake Bay Program Goals outlined in the 2017 Technical Addendum

Segment	Virginia WQS Acreage Goal	Actual Mapped SAV up to 2000) Clipped to application depth	Difference
Mesohaline James	200	605	405
Polyhaline James	300	615	315
Upper Tidal Fresh	200	372	172
Lower tidal Fresh	1000	1409	409
Mesohaline Rappahannock	1700	5500	3800

The draft 2016 integrated report suggests that the Polyhaline James River criteria (which DEQ has suggested is currently based upon attainability) has been achieved for the period of 2009-2014 and thus that the segment is meeting a level above what was once considered a threshold of attainability. However, if considering the goal outlined in the draft 2017 technical addendum which documents evidence of mapped acreages (693 acres) beyond the current standard (300 acres), this system would be assessed as not meeting this designated use (see Figure 1). Other segments (JMSTF1 and RPPMH) have also demonstrated improved responses in attainment since 2004 (the referenced date of attainability determination) which provide new information pertinent to the calculation of “attainability”⁵. This information, in combination with the fact that Virginia has only accomplished a portion of the expected TMDL pollutant reductions, and that no time has surpassed to account for a lag in response, clearly illustrates that the SAV acreage criteria were an underestimate relative to both historic thresholds and what is attainable. **As a result, we request that DEQ reconsider evaluations of attainability for these five segments.**

Attainability estimates should present a structured scientific assessment of the factors affecting the attainment of the use which may include physical, chemical, biological, and economic factors as described in 9VAC25-260-05. In the described situation, this level of assessment is either not available (JMSTF1, JMSTF2) or outdated (i.e. references to 2004 model which does not consider recent surveys; JMSMH, JMSPH, RPPMH). Such an assessment should be reevaluated for each of the five segments which have criteria which are below the mapped level identified in

which total over 4,000 acres, are justified as being based on “model attainability”. There is no discussion or mention of this model attainability other than in the Justification column of Table V-1. Was the model attainability used for all segments in the Bay? If the state’s restoration goals are incorporated into the CBP goals, will the CBP restoration acreages for these segments be reduced to equal the lower Virginia acreages? If so, what will be the implications of this change?”

⁵ 9VAC25-260-10. Designation of Uses.. “Where existing water quality standards specify designated uses less than those which are presently being attained, the board shall revise its standards to reflect the uses actually being attained.”

the recent draft addenda. This is important to ensure Virginia's water quality criteria are sufficiently protective of this designated use and also to establish equity associated with the interstate partnership which is substantially beneficial for Virginia. If DEQ finds the mapped acreages presented by CBP to be unattainable due to appropriate reasons⁶, this information should be clearly documented. Otherwise, these criteria should be revised to be consistent with the mapped acreages.

Finally, the draft 2016 integrated report, which classifies the Polyhaline James to have achieved the SAV designated use presents a clear example where the "water quality standard specifies designated uses less than those which are presently being attained" and occurs in association with a standard which is based upon attainability. As a result, this should prompt DEQ to take action to revise this standard. The recent SAV improvements which are referenced in this report, should reclassify our consideration of "attainability" in these segments (i.e. Virginia-degradation policy⁷).

While we understand the role of the integrated report is not criteria revisions, and that such a process will likely need to extend beyond the release of this report, these issues should at least be clarified in the report. Specifically, the reader should not come away with the impression that there is no SAV designated use impairment associated within the Polyhaline James River given the criteria reference was based upon attainability.

Thank you for your consideration of our comments on this important report and all of the work you do to help improve Virginia's water quality. If you have any questions regarding these comments, please feel free to contact me at 804-258-1577 or at jwood@cbf.org.

Sincerely,

Joseph D. Wood, Ph.D.
Virginia Staff Scientist
Chesapeake Bay Foundation

⁶ Ibid

⁷ 9VAC25-260-30

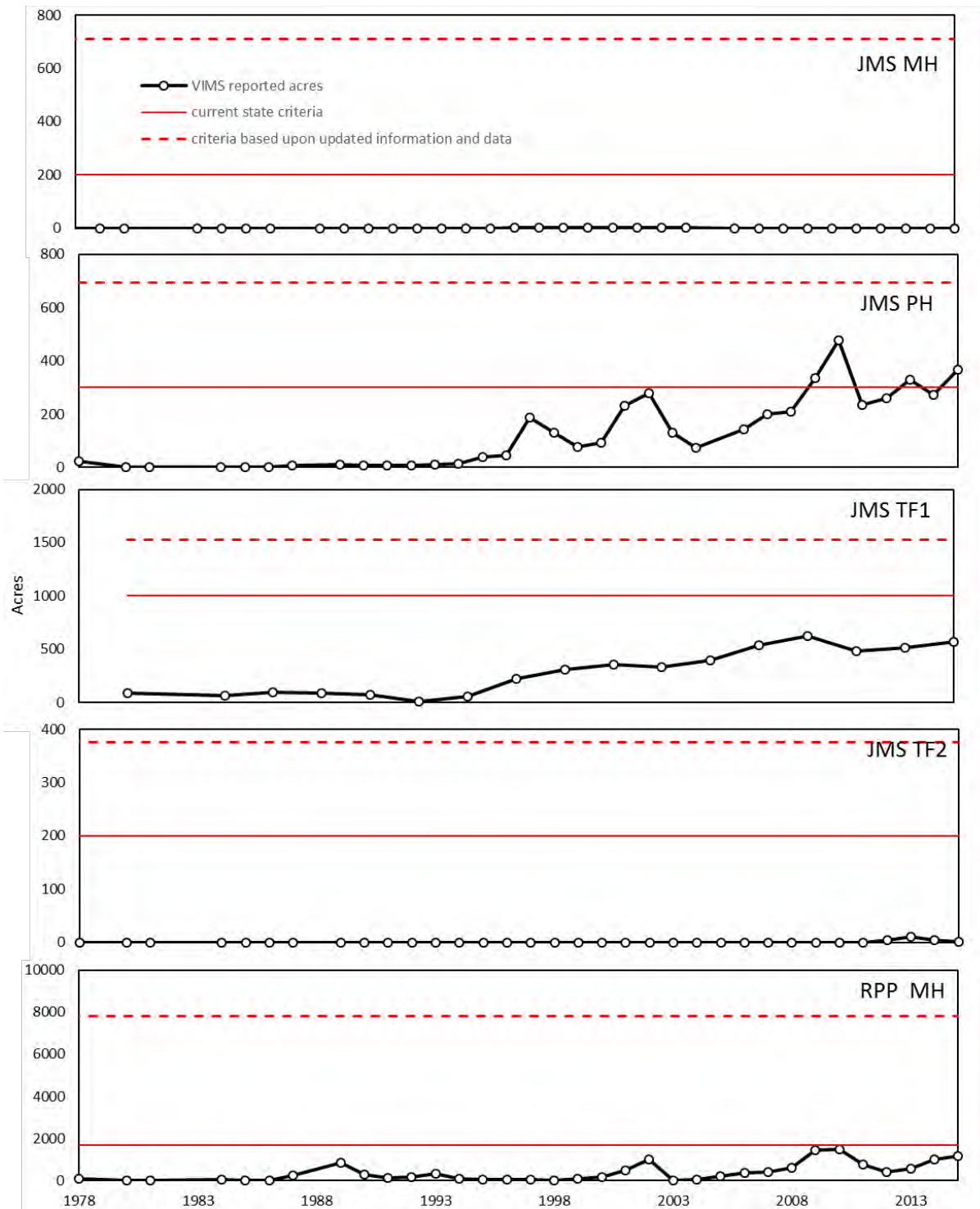


Figure 1 Annual SAV Acreages from VIMS (Orth. et al. 2016), State regulatory goals for SAVs and Mapped acres according to the 2017 Technical addendum for Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries.

DEQ Response to Chesapeake Bay Foundation

Concerns regarding Submerged Aquatic Vegetation Criteria and attainability

The SAV restoration goals for the Bay segments are published in Virginia's Water Quality Standards and are thus considered water quality criteria. The review and modification of water quality criteria to reflect best available science happens approximately every three years in a process known as Triennial Review. CBF is encouraged to bring this issue to DEQ's attention during the next Triennial Review, which is anticipated to begin in 2020.

Comments from Loudoun Watershed Watch



David Ward
Loudoun Watershed Watch
38659 Bolington Rd
Lovettsville, VA 20180
September 6, 2017

Sandra Mueller
Virginia Department of Environmental Quality
Office of Water Monitoring and Assessment
P.O. Box 1105
Richmond, VA 23218-1105

Sent via e-mail Sandra.Mueller@deq.virginia.gov
Copy posted at http://www.loudounwatershedwatch.org/subitem6_3.html

Subject: Comments on **Draft 2016 305(b)/303(d) Water Quality Assessment Integrated Report**

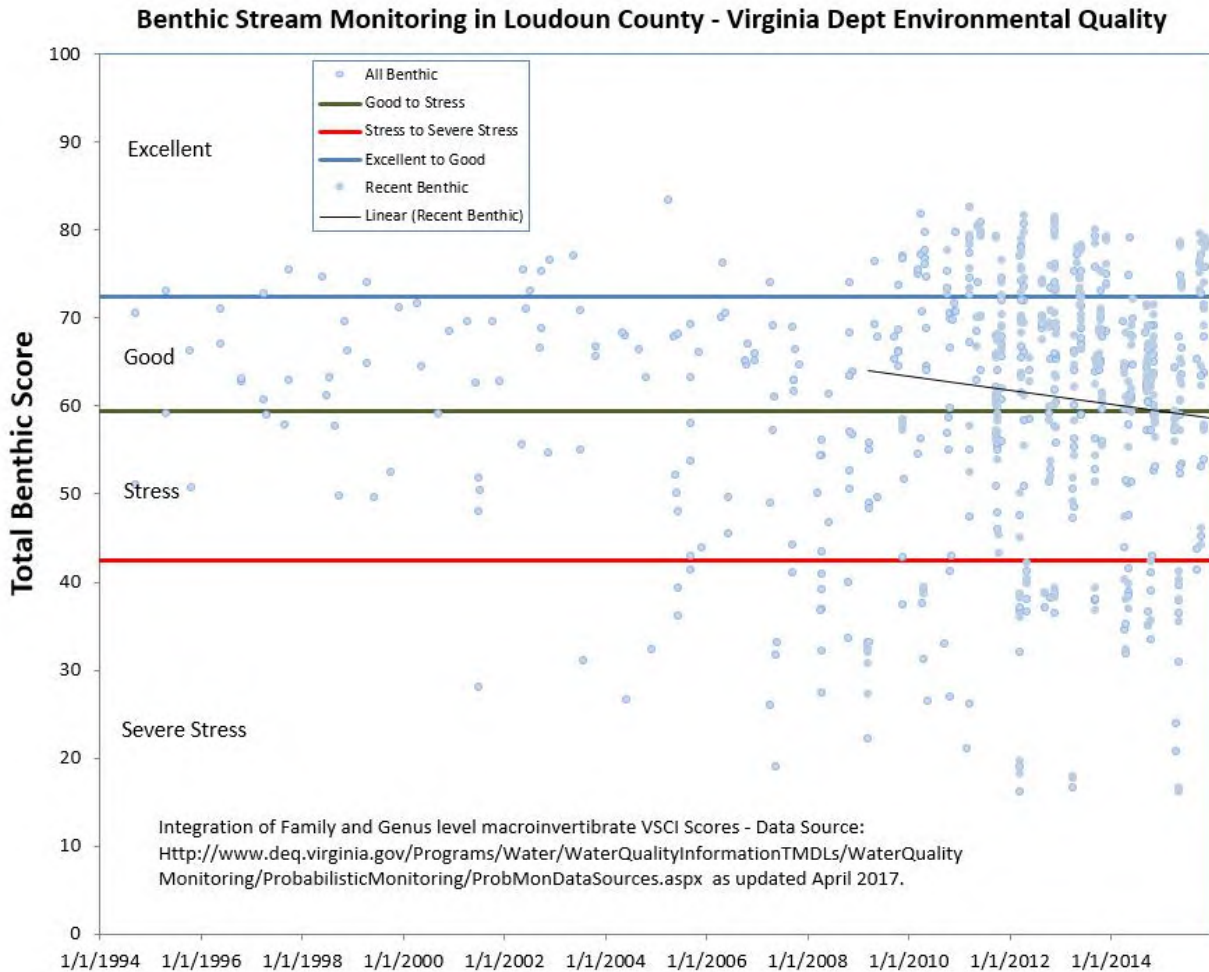
Loudoun Watershed Watch is pleased to submit comment on the DRAFT 2016 Water Quality Assessment Integrated Report appearing at
<http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityAssessments/2016305b303dIntegratedReport.aspx>

Specifically, we wish to comment on the "Delisting" in Loudoun County appearing in Appendix 3
http://www.deq.virginia.gov/Portals/0/DEQ/Water/WaterQualityAssessments/IntegratedReport/2016/ir16_Appendix3_Waters_Identified_for_Delist.pdf

There are several proposed delistings for aquatic life use (benthic) and recreational use (bacteria) in Loudoun County. We believe the benthic delisting for Little River maybe premature based on the following reasons.

1. There has not been a TMDP Implementation Plan, nor a watershed plan developed for Little River. There is a TMDL Action Plan appearing in the Loudoun County MS4 Permit Stormwater Management Plan.
2. We believe that construction and continued development (imperviousness) in this subwatershed of Goose Creek has increased over time which conflict with delisting.
3. The overall benthic scores within Loudoun County continues to decline overall and we would expect the same for the types of land use in Little River (See chart below).
4. The data for the 5-year data window is very limited and may not reflect the actual trend of Little River.
5. Examining data beyond the data window indicate that the period January 2009 to December 2014 we see that while scores in 2013 for 3 sites on Little River showed no impairment, the score in 2016 for one location showed the stream very close to the demarcation score of 60.

Using ProbMon data for Loudoun County as presented at
<http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityMonitoring/ProbabilisticMonitoring/ProbMonDataSources.aspx>, the VSCI scores were extracted from MS Access, values averaged when duplicate samples were taken and Family and Genus-level values integrated. The results are charted below with a linear trend for the 2009-2016 period.



Data are includes in Table 1 as attached to this letter

The text for the delisting on Little River are:

Potomac and Shenandoah River Basins

VAN-A08R_LIV01A00 Little River 6.41 Miles

Delisting Summary: Aquatic Life

PARTIAL DELIST 2016 - Benthic Macroinvertebrates - A08R-02-BEN, VAN-A08R-02 (CFL 1998)

During the 2014 cycle, this segment was assessed as not supporting the aquatic life use because biological monitoring events in 2008 (spring and fall) at station 1aLIV004.78 resulted in VSCI scores indicating an impaired macroinvertebrate community. Subsequent biological monitoring events (2) took place in 2013 (spring and fall) 0.01 mile upstream from this location at station 1aLIV004.79.

The 2013 events indicated a healthy aquatic community and support of the aquatic life use. The average VSCI score from the two most recent years of sampling also indicate support of the aquatic life use. It has been determined that this segment should be delisted for benthic macroinvertebrates based upon recent VSCI scores indicating a healthy benthic macroinvertebrate community.

VAN-A08R_LIV02B10 Little River 4.36 Miles

Delisting Summary: Aquatic Life

PARTIAL DELIST 2016 - Benthic Macroinvertebrates - A08R-03-BEN, VAN-A08R-02 (CFL 2010)

During the 2014 cycle, this segment was assessed as not supporting the aquatic life use because a biological monitoring event in 2008 (fall) at station 1aLIV012.12 resulted in VSCI scores indicating an impaired macroinvertebrate community. Subsequent biological monitoring events (2) took place in 2013 (spring and fall) at this location. The 2013 events indicated a healthy aquatic community and support of the aquatic life use. The average VSCI score from the two most recent years of sampling also indicate support of the aquatic life use. It has been determined that this segment should be delisted for benthic macroinvertebrates based upon recent VSCI scores indicating a healthy benthic macroinvertebrate community.

We appreciate the opportunity to comment on the water quality assessment and look forward to your response.

Sincerely,

A handwritten signature in black ink, appearing to read "David Ward". The signature is fluid and cursive, with the first name "David" and last name "Ward" clearly distinguishable.

David Ward
Loudoun Watershed Watch

Table 1

Row Labels	Stream Name	Spring 2009	Fall 2009	Spring 2010	Fall 2010	Spring 2011	Fall 2011	Spring 2012	Fall 2012	Spring 2013	Fall 2013	Spring 2014	Fall 2014	Spring 2015	Fall 2015	Spring 2016	Fall 2016	Ave_2010_2016
1ABEC004.76	Beaverdam Creek					79.58	72.21											75.90
1ABEM000.60	Beaverdam Run									50.48	37.99	38.32	35.07					40.46
1ABRB002.15	Broad Run							38.52	38.73									38.62
1ABRB006.97	Broad Run							41.27	38.70									39.98
1ABRB015.43	Broad Run							39.97	61.81									50.89
1ABSC000.45	Big Spring													39.57		33.59	52.50	41.88
1ABUL025.94	Bull Run											64.64	64.28	57.16	76.10			65.54
1ACAA007.34	Catharpin Creek					82.58	79.18											80.88
1ACAC000.16	Cattail Branch													37.86	57.53	22.14	56.82	43.59
1ACAX003.81	Catoctin Creek							64.07	74.12									69.10
1ACAX004.57	Catoctin Creek									77.99	79.27							78.63
1ACLK002.40	Clark's Run (Tributary to POT)					78.91	60.49											69.70
1ACRM004.09	Cromwells Run															67.69	62.61	65.15
1ACUB004.63	Cub Run	30.64	57.92	39.06														39.06
1ACUB011.25	Cub Run													16.38	45.22	28.44	63.15	38.30
1ACUB011.78	Cub Run															19.12	50.88	35.00
1ADRL001.00	Dry Mill Branch									67.66	79.00	64.27	62.93			28.91	72.35	62.52
1ADUT000.62	Dutchman Creek													63.09	63.46	53.19	66.49	61.56
1ADUT002.72	Dutchman Creek													58.98		45.34	69.61	57.98
1AELC001.39	Elklick Run							47.47	69.17									58.32
1AFRY000.85	Frying Pan Branch															29.75	58.10	43.92
1AGOO000.50	Goose Creek						44.30											44.30
1AGOO011.23	Goose Creek									68.86	63.88	69.97	71.47			44.97	53.55	62.12
1AGOO018.17	Goose Creek							78.15	68.72									73.43
1AGOO022.44	Goose Creek				75.25									78.44	77.24	48.40	69.64	69.79
1AGOO030.75	Goose Creek					70.18												70.18
1AGOO039.63	Goose Creek									77.14	65.15							71.15
1AGOO044.36	Goose Creek															70.60	77.06	73.83
1AHPR003.93	Horsepen Run									17.73	52.79	35.15	38.97					36.16
1AJAC000.74	Jack's Run															26.84	66.59	46.72
1AJEE000.23	Jeffries Branch									64.10	70.08	57.83	69.18		78.53			67.94
1AJEE002.22	Jeffries Branch					68.44	55.47			56.34	73.11	61.25	69.09	63.59	71.25			64.82
1AJEE004.34	Jeffries Branch													73.83	71.53			72.68
1ALII001.07	Little Bull Run													58.52		51.79	75.16	61.82
1ALIM001.16	Limestone Branch					74.53	65.71	58.32	73.33									67.97

Table 1

1ALIV004.78	Little River																60.52	61.20	60.86
1ALIV004.79	Little River									74.50	68.49								71.49
1ALIV012.12	Little River									72.47	65.22								68.84
1ANOB000.75	North Fork Beaverdam Creek									71.30	74.95	60.64	62.29				66.68	43.04	63.15
1ANOC000.42	N. Fk. Catoctin Creek					60.05							60.03						60.04
1ANOC004.38	N. Fk. Catoctin Creek					60.95	71.97	68.83					58.22						64.99
1ANOC009.37	N. Fk. Catoctin Creek					59.07							65.02						62.05
1APIA001.80	Piney Run						80.72	73.25				68.00	69.08						72.76
1APIA003.51	Piney Run				80.42	67.78													74.10
1ASAN000.34	Sand Branch																13.86	58.65	36.26
1ASAN001.45	Sand Branch																40.34	45.08	42.71
1ASIM000.42	Simpsons Creek																61.20	75.40	68.30
1ASOC002.93	South Fork Catoctin Creek																56.54	55.23	55.89
1ASOC007.06	S. Fk. Catoctin Creek					65.55	63.50	79.85											69.63
1ASOC010.09	S. Fk. Catoctin Creek					74.56	69.81	81.23											75.20
1ASOC011.70	S. Fk. Catoctin Creek					67.86	72.01	73.01											70.96
1ASOC013.05	S. Fk. Catoctin Creek					66.45	74.17	60.44											67.02
1ASOR000.59	S. Fk. Broad Run				55.00	56.67	37.04	59.16											51.97
1ASYC007.43	Sycolin Creek									66.30	59.66	43.85	66.34				48.48	65.02	58.27
1ATUS003.19	Tuscarora Creek						18.91	52.85											35.88
1AXJI000.38	X-Trib to Goose Creek																82.63		82.63
1AXOB000.17	UT to Bull Run																61.39	64.38	62.88

DEQ Response to Loudoun Watershed Watch

Little River Benthic Delisting

The VSCI scores for the 2016IR assessment period (2009-2014) indicate aquatic life use attainment for these two segments of Little River based on benthic macroinvertebrate bioassessments, which is why DEQ has proposed delisting these segments. The information that DEQ agrees to use in assessments, per guidance, does not support classifying these two segments of Little River as impaired at this time. The calendar year 2016 VSCI scores will be included in assessment for the 2018IR. If these data, or any other new data, indicate in the future that either or both of these stream segments are impaired for benthic macroinvertebrates, they will be returned to the list of impaired waters. DEQ will continue to monitor and assess Little River as resources allow.

In addition to benthic macroinvertebrate bioassessments, there were other sampling results that were considered in the assessment of the aquatic life use for these stream segments. Field parameters and toxics assessment indicated that the aquatic life use was supported along the applicable assessed length of Little River.

Please note that DEQ encourages citizens to participate in water quality monitoring and data submitted to DEQ by citizen monitoring groups can be considered during assessment. While there were no citizen biological data submitted for the two segments of Little River proposed for delisting, there were biological data submitted for the assessment period for the upstream portion of Little River. These data were considered to be Level II; as such, they were not applicable for making impairment decisions. However, they indicated that there was a low probability of adverse conditions for biota.

While reviewing the comments submitted by Loudoun Watershed Watch for the 2016IR, DEQ noted that the VSCI scores included in Table 1 of the comments document were not necessarily the same as those DEQ uses for assessment. DEQ encourages Loudoun Watershed Watch to contact DEQ's Northern Regional Office to discuss the procedures used to extract scores from the database.

Comments from Virginia Association of Municipal Wastewater Agencies



VIRGINIA ASSOCIATION OF MUNICIPAL WASTEWATER AGENCIES, INC.

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Augusta County Service Authority
Blacksburg-VPI Sanitation Authority
County of Chesterfield
Town of Christiansburg
Coeburn-Norton-Wise Reg. Wastewater Auth.
Town of Culpeper
City of Danville
County of Fairfax
Frederick County Sanitation Authority
Frederick-Winchester Service Authority
Hampton Roads Sanitation District
County of Hanover
Harrisonburg-Rockingham Reg. Sewer Auth.
County of Henrico
City of Hopewell
Town of Leesburg
Loudoun Water
City of Lynchburg
City of Martinsville
Pepper's Ferry Regional Wastewater Auth.
Prince William County Service Authority
City of Richmond
Rivanna Water and Sewer Authority
South Central Wastewater Authority
County of Spotsylvania
County of Stafford
Upper Occoquan Service Authority
City of Waynesboro
Western Virginia Water Authority
City of Winchester

ASSOCIATE MEMBER AGENCIES

Amherst County Service Authority
Town of Amherst
Bedford Regional Water Authority
Town of Bowling Green
City of Buena Vista
County of Campbell
County of Caroline
Town of Colonial Beach
County of Culpeper
D.C. Water
Dinwiddie County Water Authority
Fauquier County Water & Sanitation Auth.
City of Fredericksburg
Town of Front Royal
County of Goochland
Halifax County
Henry County Public Service Authority
Town of Kilmarnock
Louisa County Water Authority
Maury Service Authority
Montgomery County Public Service Auth.
County of New Kent
Town of Onancock
County of Powhatan
Town of Purcellville
Rapidan Service Authority
Stoney Creek Sanitary District
Town of Strasburg
Sussex Service Authority
Town of Tappahannock
Town of Warsaw
Wise County Public Service Authority
Town of Woodstock

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AquaLaw PLC

September 1, 2017

By Email (Sandra.Mueller@deq.virginia.gov)

Ms. Sandra Mueller
Virginia Department of Environmental Quality
Office of Water Monitoring and Assessment
P.O. Box 1105
Richmond, Virginia 23218-1105

Re: Draft 2016 Water Quality Assessment Integrated Report

Dear Ms. Mueller:

Please accept the following comments on the Department's draft 2016 305(b)/303(d) Water Quality Assessment Integrated Report. These comments are submitted on behalf of the Virginia Association of Municipal Wastewater Agencies and its Water Quality Committee. As you may know, VAMWA is an incorporated association of Virginia municipalities owning and operating Publically Owned Treatment Works. VAMWA's mission is the protection and promotion of water quality through the application of good science.

We appreciate the Department's efforts on the draft Report. We have only two comments, both of which are supportive of the draft.

Algae and Possible Impairment of the Recreational Use

First, we note that the several segments of the North and South Forks of the Shenandoah River over which there have been public concerns about excessive algae and possible impairment of the recreational use continue to be characterized under Category 3C – observed effects but with insufficient data to properly determine whether the designated use is affected. The 3C categorization is proper because of (1) the non-QA/QC approved data and reports submitted by the interested citizens; (2) the necessarily subjective nature of their observational data; (3) the current absence of relevant water quality criteria or other objective means of assessment of the use; and (4) the Department's ongoing process to evaluate and develop an approach to such assessment. It would in our view not be possible to accurately make an assessment of use attainment under the current circumstances, much less to do so consistently among multiple water segments.

We support the Department's current efforts involving Shenandoah field work during the 2016 and 2017 summer seasons, the evaluation of field methods, and the determination and confirmation of consistency between the visual and

Ms. Sandra Mueller

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quantitative measures of potentially nuisance algae growth; as well as the follow-up determination of use assessment criteria. As we know the Department is, we are hopeful that this process will lead to scientifically-based, defensible and reproducible assessment capabilities.

Further, as the Department has noted, nutrients present multi-faceted issues and solutions, several of which are ongoing including Chesapeake Bay TMDL efforts, and all of which address in a positive manner the underlying nutrient effects on the recreational use. Given these factors, the 3C classification is proper and the Department's current process is the best approach toward assessment of the recreational use.

TMDL Alternatives

Second, we support the Department's efforts in exploring opportunities for TMDL alternatives development, and the availability and use of category 5R – water segments in which implementation of a restoration plan is expected to result in use attainment. The exploration of alternative approaches is proper because clearly the TMDL structure is not appropriate or the most effective approach in all cases.

In particular we note the Appendix 1a "H" coding for several segments listed for PCBs, which we understand to denote waterways for which an alternative approach may be effective. In appropriate cases these impairments may have little or no contribution of PCBs from point sources, or any such contributions may be identifiable as pass-through POTW sources in which the PCBs originate in the surface waters or groundwaters that feed the public and private potable water supply systems, and in turn make up the POTW influent. In such cases a restoration program focusing on the existing sediments as well as air deposition and any other non-point sources may be beneficial and ultimately effective.

For a mature program like the 303(d) impaired waters program, we believe determinations of impairments that may benefit from an alternative approach may be made accurately, and the alternative approaches may benefit water quality more effectively and sooner than a traditional TMDL approach.

Again, we appreciate the Department's efforts on the 2016 Integrated Report, and we look forward to continuing to work with the Department on water quality efforts.

Sincerely,

A handwritten signature in cursive script, reading "Michael J. McEvoy".

Mike McEvoy
President

cc: VAMWA Board
VAMWA Water Quality Committee
Christopher D. Pomeroy, Esq.

DEQ Response to Virginia Association of Municipal Wastewater Agencies

Algae and Possible Impairment of the Recreational Use

We appreciate VAMWA's support of the agency's ongoing efforts to accurately characterize the possible nuisance algae growth in several Shenandoah River segments. We look forward to your feedback on proposed impairment thresholds in the 2018 Water Quality Assessment Guidance.

TMDL Alternatives

In regards to PCB TMDLs, DEQ has yet to find a waterbody that does not have an appreciable load from point sources. It is highly unlikely that a point source PCB concentration would be simply attributed to pass-through. We often see a 90-95% reduction in effluent when compared to the influent.

'H' means it is a high priority for TMDL development. However, DEQ reserves the right to pursue a TMDL alternative if the circumstance is best suited for an alternative and/or the Technical Advisory Committee are in agreement with the approach. More on TMDL alternatives from the 2016 Integrated Report presented below for your reference.

EPA's 2016 IR Guidance acknowledges that restoration plans that serve as alternatives to TMDLs may be the best option to reach water quality standards faster. However, when the TMDL alternative lacks enforceable "other pollution control requirements," the water cannot be assessed as 4B, and must remain in category 5. In EPA's 2016 IR Guidance the national subcategory of 5-alternative is discussed and introduced. In Virginia this is the state subcategory 5R (detailed description below).

EPA specifically recommends that the 5R documentation describe the following six minimum elements:

- a) The identification of the point and nonpoint sources. For point sources, an analysis should be included to document whether they are causing or contributing to the water quality impairments. If it is determined that the point sources are causing or contributing, then a Water Quality Based Effluent Limitation (WQBEL) or Best Management Practices Approach² should be developed and implemented through NPDES permits.
- b) The point source and nonpoint source water quality restoration activities that are expected to result in water quality improvements and restoration. Where applicable, describe any authorities that may require water quality controls to be implemented (e.g., state or local regulations, permits, contracts and grant/funding agreements).

c) Cost estimates and funding commitments to implement the water quality restoration activities. In order to provide assurance that water quality restoration can occur through the implementation of water quality restoration activities, cost estimates and secured funding sources that will be used to implement these activities should be identified.

d) An anticipated schedule for implementing the water quality restoration activities, including the anticipated completion date and the estimated pollutant load reductions necessary to meet water quality standards. The schedule should outline specific activities and include a timeline of when each phase will be implemented and accomplished. The schedule can be revised and updated at each 303(d) listing cycle.

e) A water quality monitoring component to evaluate and track the effectiveness of the scheduled water quality restoration activities at each 303(d) listing cycle. Baseline water quality conditions should be established in order to accurately measure water quality progress. At each 2-year 303(d) listing cycle, performance measurements, whether environmental, programmatic, or social, should be provided for each implemented water quality restoration activity to measure progress. It is understood that each water restoration activity may not result in improved water quality; however the combined restoration activities should result in improved water quality at each 303(d) listing cycle.

f) An anticipated date for achieving water quality standards. Projects are expected to follow adaptive management allowing critical milestones to be adjusted as project plans and goals may change as implementation occurs. Once water quality standards have been met, the State may determine that the waterbody is appropriate to be included in category 1 or 2. If the project does not meet water quality standards by the estimated completion date, sufficient trends toward improved water quality must be shown in order to continue in the 5R program and an updated implementation schedule including revised critical milestones should be submitted to EPA. The project will continue to be reviewed every 2-year 303(d) listing cycle until water quality standards are met.

Comments from Waterkeepers Chesapeake



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Takoma Park, MD 20913-1075
(202) 423-0504
info@waterkeeperschesapeake.org

September 6, 2017

Ms. Sandra Mueller
VA DEQ – Office of Water Monitoring and Assessment
P.O. Box 1105
Richmond, Virginia 23218
via email: sandra.mueller@deq.virginia.gov

Re: Comments on *Virginia's Draft 2016 Integrated Report of Surface Water Quality*

Dear Ms. Mueller,

Thank you for the opportunity to comment on Virginia's Draft 2016 Integrated Report of Surface Water Quality ("IR"). Waterkeepers Chesapeake is a coalition of 19 independent Waterkeeper & Riverkeeper programs (including the Potomac Riverkeeper Network, James River Association, and Shenandoah Riverkeeper) that work locally, using grassroots action, advocacy, and legal action to protect their communities and waterways.

We point out the following specific areas of concern regarding Virginia's Draft 2016 IR:

1. Even after several years, impaired segments of waterways listed as Category 5 have not yet received required TMDLs.

Federal regulations set forth at 40 C.F.R. § 130.7(c)(1) require TMDLs to meet the following basic minimum requirements:

TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical [water quality standards] with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality. Determinations of TMDLs shall take into account critical conditions for stream flow, loading, and water quality parameters.

By comparing the 2016 IR and the 2014 IR, it becomes clear that many waterways listed as "Category 5" in 2014 have not yet received a TMDL. According to the Clean Water Act §303 (d)(1), every state must identify impaired waters, rank those waters in terms of severity of pollution, and assign TMDLs to those waters in accordance with the priority ranking. As Virginia's Department of Environmental Quality (DEQ) is well aware, when a waterway is listed as a Category 5 it means that the body of water is impaired, or does not attain water quality standards and needs a TMDL; this is the classic list of Section 303 (d) waters. It's unclear why these waterways have not received a TMDL over the years.

Anacostia Riverkeeper
Assateague Coastkeeper
Baltimore Harbor Waterkeeper
Chester Riverkeeper
Choptank Riverkeeper
Gunpowder Riverkeeper

Lower James Riverkeeper
Lower Susquehanna Riverkeeper
Miles-Wye Riverkeeper
Potomac Riverkeeper
Sassafras Riverkeeper
Severn Riverkeeper

Shenandoah Riverkeeper
South Riverkeeper
Upper James Riverkeeper
Upper Potomac Riverkeeper
Virginia Eastern Shorekeeper
West Rhode Riverkeeper



A long list of waterways in Virginia's Potomac and Shenandoah River basins have not received a TMDL for *over nine years now*, despite being listed as a Category 5. These waterways include parts of the James River, Potomac River, Shenandoah River, Occoquan River, North River, South River, Dry River, Little Wicomico River, Chickahominy River, Jackson River, Bullpasture River, Calfpasture River, Saint Marys River, Maury River, Appomattox River, Hughes River, Robinson River, Rose River, Rappahannock River, Roanoke River, Blackwater River, Little Otter River, Dan River, Meherrin River, Nottoway River, Northwest River, North Fork Catoctin Creek, Clarks Run, Wancopin Creek, North Fork Beaverdam Creek, Broad Run, Captain Hickory Run, Difficult Run, Pimmit Run, Indian Run, Holmes Run, Tripps Run, Accotink Creek, Long Branch, Pohick Creek, Lucky Run, Bull Run, Flatlick Branch, Sandy Run Neabsco Creek, Powells Creek, Quantico Creek, Aquia Creek, Thompson Branch, Strait Creek, Lewis Creek, Long Meadow Run, Wolf Run, Briery Branch, Rocky Run, Union Springs Run, Switzer Lake, Dry River, Loves Run, Back Creek, Mills Creek, Coles Run, Johns Run, Kennedy Creek, Orebank Creek, Paine Run, Meadow Run, Deep Run, and the list goes on.

A significant of the waterways that were listed in the 2014 IR as Category 5 – such as Homes Run, Tripps Run, Accotink Creek, Bull Run, Occoquan River, Lewis Creek, Wolf Run, etc. – with TMDL development dates set for 2016 still do not have a TMDL in the 2016 Draft IR.

There is little to no justification for why these impaired waterways have not yet received a TMDL over the years, some of which have been listed for over a decade. Further, some of the justifications in the notes section of the 2016 IR are exactly the same as the 2014 IR. Solely by looking at parts of the James River and Potomac Rivers, which have not received a TMDL, it becomes clear that there were absolutely no changes from the 2014 IR to the 2016 IR in terms of associated notes for PCBs in fish and public water supplies, E. Coli in recreational waters, pH issues impairing aquatic life, among other issues that cause environmental harm and public health concerns. This is the same for many other waterways. It is important that DEQ assign TMDLs to these waterways to ensure that water quality standards are being attained and that Virginia's anti-degradation policy is being followed.

2. Impaired segments covered by the Chesapeake Bay TMDL still require local TMDLs.

DEQ should reverse its decision to remove hundreds of impaired segments of waterways from Virginia's Category 5 list of impaired waters due to the Chesapeake Bay TMDL in the 2012 IR, 2014 IR, and 2016 draft IR. Many of the water segments removed from the Category 5 list of impaired waters needing a TMDL and placed on the Category 4a list only had conclusive statements about their reasons for removal. For instance, in the 2016 IR, for a segment of the James River that was partially delisted, there is a lack of clear explanation for why the segment was delisted along with, "The Chesapeake Bay TMDL was approved by the EPA on 12/29/2010; therefore, it will be considered Category 2C." Under the Chesapeake Bay TMDL, the EPA stated that "in some cases, the reductions required to meet local conditions shown in existing TMDLs may be more stringent than those needed to meet Bay Requirements."¹ A local TMDL is needed

¹ Chesapeake Bay TMDL at 2-6.

for many of the water segments listed in Category 4a because the Chesapeake Bay TMDL is not localized to address specific needs of certain waterways and, in many cases, is less stringent than those DEQ previously determined.

Rather than providing substantive responses to the concerns expressed in public comments, DEQ referred commenters to the Chesapeake Bay TMDL documentation. DEQ did not assess or explain how the Bay TMDL incorporated sufficient local-level water quality data, records on every permitted sources discharging to the segment, information on local hydrology, weather, and any other data or information needed to ensure the that the model produces TMDLs sufficiently stringent to restore the local segments to water quality standards. Consequently, DEQ also failed to address the fact that many sources encompassed in the Bay TMDLs received only aggregate allocations, or no individual wasteload allocations at all. Whatever EPA's reasons for these decisions in the context of the Chesapeake Bay TMDLs, DEQ has an independent duty to ensure that adequate TMDLs exist both to protect local water quality and to inform source-specific effluent limitations in permits. DEQ should disclose its analysis of pre-existing TMDLs through Integrated Reporting, not in a separate document or process.

The clear need to conduct detailed local analyses is also discussed in the 2008 *Scientific and Technical Advisory Committee Chesapeake Bay Watershed Model Phase V Review* (February 20, 2008) (the "STAC" report). EPA recruited the STAC as an "independent panel of experts to review the Chesapeake Bay Watershed Model (CBWM) Phase 5 effort." Among other topics, the expert STAC reviewers were asked to assess "the model's suitability for making management decisions at the Bay Watershed and local scales." In the Review, the STAC explained its view that the "scale of information" built into the model was **not** appropriate for local TMDLs, and recommended that local TMDLs should employ the CBWM Phase 5 using additional local information not included in the Chesapeake Bay TMDL modeling effort:

- a. This question was discussed at length with the CBWM team. We agree with the team that the current CBWM implementation *is not appropriate for development and implementation of TMDLs at the local watershed scale*. A major barrier appears to be the scale of information built into the CBWM, which is based on the county level data and river reach segmentation at the 100 cfs threshold and designed for full watershed or major tributary scale analysis.
- b. A potential approach is to make use of community modeling framework in which local watershed managers could make use of additional modeling tools and data to *resegment, recalibrate and implement the model at appropriate local scales using more site specific local information*. Local- scale data can be obtained from specific sampling and measurement, or from higher-resolution spatial data sources and modeling tools."²

In response, the EPA acknowledged that "the refinement of spatial scale from Phase 4 to Phase 5 [of the CBWM] allows Bay Program States to consider its use in localized TMDLs."³

² Emphasis added.

³ EPA, *Response of the Modeling Subcommittee to the Second STAC Review of the Phase 5 Community Watershed Model* at 5 (Jan. 28, 2009).

DEQ's failure to perform such an analysis clearly is not attributable to technical limitations, as evidenced by the relatively detailed local analyses undertaken by DEQ in pre-2010 "nearfield" TMDLs. Indeed, EPA's own decision not to employ a finer scale of local information was based solely upon the lack (as of 2009) of "consistent" local data at a finer scale for all of the segments covered by the multi-state Bay TMDLs. For its own purposes in completing the Chesapeake Bay TMDLs, EPA concluded that it was sufficient to use "all available data at the finest *consistent* scale possible within the Bay watershed."⁴ DEQ is not affected by such a limitation. In determining to reclassify the relevant local impairment listings into Category 4a, DEQ does not face the burden of trying to gather local information for the entire Chesapeake Bay watershed.

3. DEQ has failed to gain any new information on many waterways listed as Category 3 over the years.

Many waterways listed as Category 3 have been listed as such for many years now, with no progress made on obtaining any new information to decide whether water quality standards are being met. Even Category 3b waterways have not been reassessed. According to the 2016 IR, Category 3b listings mean that "some data exists but it is insufficient to determine support of any designated uses. Such waters will be prioritized for follow up monitoring." A tributary to the Choptank Creek has remained on the Category 3b list since the 2014 IR.

Throughout the 2016 IR, many bodies of water are listed as Category 3c with no action taken for at least two years. Under the 2016 IR, water segments that are listed as Category 3c shows that "data collected by a citizen monitoring or other organization indicate water quality problems may exist but the methodology and/or data quality has not been approved for a determination of support of designated use(s). These waters are considered as having insufficient data with observed effects. Such waters will be prioritized by DEQ for follow up monitoring." While DEQ stated that these waterways would be a priority for follow up monitoring, no action has been taken for over 40 water segments. Only a handful of these waterways were removed from the 3b list altogether. Some of the waterways have been listed for significantly more than two years. It is important that DEQ gather more information on these waterways and work with local water quality organizations to ensure that water quality standards are being attained and that Virginia's anti-degradation policy is being followed.

4. DEQ should make clearer any designation changes from previous IRs for increased public participation and awareness.

In order to assess any changes to designations from previous reports, DEQ should simply add a column to the Appendix 1 Integrated List of All Waters in Virginia that includes the waterway's designation from the prior report. This would make it easier for the public to see whether there have been any changes, improvements, degradations, or assigned TMDLs over the prior two years. This information is essential not only for transparency, but will allow citizens and water quality organizations to more easily assess whether water quality standards are being attained in their watersheds.

⁴ *Id.* Emphasis added.

Thank you for your time and consideration of these comments. We look forward to working with you to ensure that Virginia waterways are attaining water quality standards.

Sincerely,

A handwritten signature in black ink, appearing to read 'Betsy Nicholas', with a stylized, flowing script.

Betsy Nicholas

Waterkeepers Chesapeake

DEQ Response to Waterkeepers Chesapeake

Even after several years, impaired segments of waterways listed as Category 5 have not yet received required TMDLs

Recently, the DEQ Watershed Program Office has worked to prioritize all Category 5 waters for TMDL work under the new Clean Water Act 303(d) Program Vision. The Vision introduces six new program enhancements with an emphasis on improving overall efficiency of the 303(d) program. The six program enhancements are addressed through the Vision goals that include prioritization, assessment, protection, alternatives, engagement, and integration.

DEQ prioritization of impaired waters for TMDL or TMDL alternative development is currently over a six year window (2016-2022). A description of the process and a list of waters with city/county information can be found at:

<http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/TMDL/TMDLDevelopment/TMDLProgramPriorities.aspx>

Impaired segments covered by the Chesapeake Bay TMDL still require local TMDLs

The Chesapeake Bay TMDL is considered a local TMDL for tidal waters of the Chesapeake Bay (tributaries included) that are impaired for DO, SAV, and chlorophyll. Although we often speak of the Bay TMDL as if it is a single pollution budget for one waterbody, it actually assigns three individual budgets for each Bay segment—all 92 of them. The Bay TMDL assigns segment-specific wasteload and load allocations for sediment, nitrogen and phosphorous, and load calculations are based on both basin and segment-specific information. These segment-specific TMDLs are designed to meet water quality standards in each Bay segment. It is hard to conceive of a framework that could be more refined than this that still accounts for the complexity of estuarine hydrodynamics. It is important to note that only tidal segments with dissolved oxygen and water clarity impairments are considered Bay TMDL “4A” waters. VADEQ does not assume the Bay TMDL will necessarily address nutrient and sediment-related impairments in the non-tidal waters of the Bay watershed. Local TMDLs are developed for these waters.

Virginia is currently developing the Phase III Watershed Implementation Plan (WIP) which will include an update of state and federal strategies and the identification of new pollutant reduction strategies needed to address the Chesapeake Bay TMDL. The Phase III WIP will also include a more focused and sustained local engagement effort and local strategies. The planning for the Phase III WIP includes a midpoint assessment, which is a review of the progress Virginia has made toward meeting the nutrient and sediment pollutant load reductions necessary for Bay restoration. Under the 2017 midpoint assessment, the Chesapeake Bay Watershed Model is being updated with the latest available science and new modeling tools (updated monitoring data and improved land use information) so that resource managers can verify whether the

implementation plans developed for the original Bay TMDL are sufficient to restore and maintain applicable water quality to all segments of the Chesapeake Bay. The improved modeling tools will enhance decision support and facilitate meeting the remaining challenges to implementation.

In response to the comment about the 2008 STAC report, we do not agree with the commenter's interpretation of the report findings. The STAC report does not suggest that the Phase 5 model is inappropriate for developing tidal tributary TMDLs. The "scale of information" issue refers instead to the local watershed scale, not the bay segment scale at which the Bay TMDLs were developed. The local watershed is the smallest level of segmentation in the Phase 5 Model. Conversely, each bay segment comprises the drainage area to a tidal tributary, and is typically composed of multiple river segments.

DEQ has failed to gain any new information on many waterways listed as Category 3 over the years

DEQ Regional Offices develop annual monitoring plans to meet the goals of the agency water monitoring strategy. As resources allow, follow up monitoring is conducted at sites/waters listed as Category 3B.

DEQ plans to revise their monitoring strategy in 2019 and will consider a greater emphasis on follow up monitoring for Category 3B waters.

DEQ should make clearer any designation changes from previous IRs for increased public participation and awareness

Thank you for your comment, we will take it into consideration as we develop the 2018 Integrated Report.

Comments from Earthjustice/Potomac and Shenandoah Riverkeepers



September 6, 2017

Submitted via email to Sandra.Mueller@deq.virginia.gov

Sandra Mueller
Virginia Department of Environmental Quality
Office of Water Monitoring and Assessment
P.O. Box 1105
Richmond, VA 23218-1105

Re: Draft 2016 Virginia 305(b)/303(d) Water Quality Assessment Integrated Report

Dear Ms. Mueller,

As in prior years we have observed the presence of excessive algae in different locations throughout the North Fork, South Fork, and main stem of the Shenandoah River, and have observed that these conditions interfere with or diminish the ability of our members and other water-users to engage in recreation including swimming, wading, floating, canoeing, aesthetic enjoyment, and fishing. This year and the prior one have been no different, as demonstrated by the vivid photographs enclosed as Attachment A. Today we are re-submitting the Technical Review we submitted with our comments on the 2014 Draft Integrated Report, which demonstrates beyond any reasonable doubt that existing effluent limits are not stringent enough to fully implement Virginia's narrative water quality standards or designated uses relating to algae in the Shenandoah River.¹ We urge the Department to fulfill its duty to identify the North Fork, South Fork, and main stem of the Shenandoah River as impaired (Category 5) due to widespread algae blooms fueled by uncontrolled or poorly-controlled pollutants including nitrogen, phosphorus, and sediment, as required by section 303(d) of the Clean Water Act, 33 U.S.C. § 1313(d).

I. Virginia's Mandatory Duty To Assess The Evidence Presented And Identify The Shenandoah River As Impaired

The Clean Water Act requires that "[e]ach State shall identify those waters within its boundaries for which the effluent limitations required by section 1311(b)(1)(A) and section 1311(b)(1)(B) of [the Act] are not stringent enough to implement any water quality standard applicable to such waters." 33 U.S.C. § 1313(d)(1)(A). Designated uses are water quality standards by definition. *Id.* § 1313(c)(2)(A). Accordingly, when evidence demonstrates that water quality standards or designated uses are not being attained despite the application of technology-based effluent limitations, the state "shall identify those waters" in its Integrated Report.

¹ Attachment B, David Sligh, Technical Review of Evidence to Determine the Presence, Extent, and Consequences of Excessive Algal Growths in the Shenandoah River and its Tributaries (January 2015).

EPA regulations that govern each state's listing process further require that "[e]ach State shall assemble and evaluate all existing and readily available water quality-related data and information to develop the [impaired waters] list..." including, "[a]t a minimum... all of the existing and readily available data and information about the following categories of ... (iii) [w]aters for which water quality problems have been reported by local, state, or federal agencies; members of the public; or academic institutions." 40 C.F.R. § 130.7(b)(5)

A. Relevant Virginia water quality standards

The water quality standards that are applicable to the Shenandoah River and relevant to excess algal growth include the following:

A. All state waters, including wetlands, are designated for the following uses: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish.

9 Va. Admin. Code § 25-260-10.A. (emphasis added).

A. State waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life.

Specific substances to be controlled include, but are not limited to: floating debris, oil, scum, and other floating materials; toxic substances (including those which bioaccumulate); substances that produce color, tastes, turbidity, odors, or settle to form sludge deposits; and substances which nourish undesirable or nuisance aquatic plant life. Effluents which tend to raise the temperature of the receiving water will also be controlled. * * *

9 Va. Admin. Code § 25-260-20 (emphasis added).

When the Virginia Water Control Board enacted these water quality standards in 1981, its statement of basis and purpose made clear that the Board intended both narrative and numeric limits to be given force and effect:

Water quality standards consist of narrative statements that describe water quality requirements in general terms, and of numeric limits for specific physical, chemical, biological or radiological characteristics of water. These narrative statements and numeric limits describe water quality necessary to meet and maintain reasonable and beneficial uses such as swimming and other water based recreation, public water supply and the propagation and growth of aquatic life. Standards include general as well as specific descriptions, since not all requirements for water quality protection can be

numerically defined.²

The Court of Appeals of Virginia has confirmed that the requirement to protect designated uses has independent force and effect in addition to the requirement to implement other water quality standards. *See State Water Control Bd. v. Captain's Cove Util. Co., Inc.*, 2735-07-1, 2008 WL 2963851 (Va. Ct. App. Aug. 5, 2008) (reinstating water pollution control board's denial of discharge permit on basis that the discharge would impair recreational uses). The court noted that "9 VAC 25–260–20 is written in the disjunctive, prohibiting substances in state waters that either contravene established standards or interfere directly or indirectly with designated uses of such water." *Id.* (emphasis in original).

The available evidence demonstrates that Virginia's existing effluent limitations are insufficient to support the recreational designated use and ensure attainment of related water quality standards for the North Fork, South Fork, and main stem of the Shenandoah River. Our enclosed 2014 Technical Review sets forth extensive evidence of impairment including:

- Over one hundred and twenty citizen complaints identifying algae blooms by location and date, and describing impairment of recreational uses including primary contact recreation, boating, wading, fishing, and general aesthetic enjoyment;
- More than 1,000 photographs and videos, including information on location and date, showing excessive growth of algae;
- Data from a summer 2012 quantitative survey of stream transects for algae conditions in the Shenandoah River; and
- Satellite images in which spectral reflective signatures of several substances in the North Fork Shenandoah River are shown, indicating high concentrations of chlorophyll and phycocyanin (the pigment in blue-green algae or cyanobacteria).

In addition, the images contained in Attachment A provide evidence that these conditions have persisted through today. Collectively this evidence provides an overwhelming basis for finding that excess nutrients are present in quantities that, in combination with other environmental factors, cause frequent widespread algae blooms that interfere with attainment of Virginia's recreational designated use and related water quality standards.

B. EPA guidance on water quality assessment and listing decisions

In its 2014 guidance on Integrated Reporting the U.S. Environmental Protection Agency (EPA) provided important information that is relevant in this context.³ Among

² Attachment C, Commonwealth of Virginia State Water Control Board, Water Quality Standards (eff. Dec. 12, 1981) (excerpt). The current water quality standards at 9 Va. Admin Code Ch. 260 are derived from this 1981 enactment.

³ Attachment D, U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Memorandum, Information Concerning 2014 Clean Water Act Sections 303(d), 305(b), and 314 Integrated

other things, EPA confirmed that visual assessments provide a valid basis for listing a waterbody as impaired:

A State can determine whether a waterbody is attaining its applicable narrative nutrient or other relevant narrative criteria and designated uses by using results of visual assessments. For example, field observations of excessive algal growth, macrophyte proliferation, adverse impacts on native vegetation (e.g., eelgrass), presence or duration of harmful algal blooms, unsightly green slimes or water column color, and/or objectionable odors may be a basis to include a waterbody on the State's Section 303(d) list for failing to meet one or more applicable narrative criteria and designated uses.

In addition, EPA affirmed that a state must list waters as impaired if their designated uses are threatened, even if the precise causes are not fully known:

[I]f a designated use is not supported and the segment currently fails to meet an applicable water quality standard or is "threatened," it must be included on the State's Section 303(d) list even if the specific pollutant causing the water quality standard exceedance is not known at the time.

EPA's Guidance for 2016 integrated reporting points back to and extends this direction to Virginia and other states for the Integrated Report process now underway, stating in particular that, "[f]or States without nutrient-related assessment methodologies, there is still a requirement to assemble and evaluate all existing and readily available water quality-related data and information against all applicable numeric and narrative [water quality standards] to develop the CWA 303(d) list."⁴ This guidance is consistent with EPA regulations requiring that Virginia "shall assemble and evaluate all existing and readily available water quality-related data and information to develop the [impaired waters] list..." 40 C.F.R. § 130.7(b)(5).

C. Relevant assessment approaches in other states

Relevant listing approaches in other states provide workable methods for assessing the how excess algal growth prevents attainment of water quality standards. For example, Vermont considers water bodies to be impaired when "[a]n on-going record of public complaint concerning the algal conditions in the water has been established."⁵ Montana's

Reporting and Listing Decisions; also available online at: https://www.epa.gov/sites/production/files/2015-10/documents/final_2014_memo_document.pdf (last visited Sept. 5, 2017).

⁴ Attachment E, EPA, Office of Wetlands, Oceans, and Watersheds, Information Concerning 2016 Clean Water Act Sections 303(d), 305(b), and 314 Integrated Reporting and Listing Decisions at 10 (Aug. 13, 2015), also available at: https://www.epa.gov/sites/production/files/2015-10/documents/2016-ir-memo-and-cover-memo-8_13_2015.pdf (last visited Sept. 5, 2017) (emphasis added).

⁵ Attachment F, Vermont Surface Water Assessment and Listing Methodology at 23 (March 2016); also available online at: http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/WSMD_assessmethod_2016.pdf (last

approach is similar: “Some circumstances related to excess nutrient pollution are severe enough that a rigorous data collection effort is not required. Photo documentation will suffice.”⁶ These approaches are appropriate for assessing nonattainment of Virginia’s water quality standards, since the designated use and the general criteria prohibiting “undesirable or nuisance” both implicate visual impacts of algae.

The Technical Review re-submitted in support of these comments provides additional background demonstrating the validity of visual assessments and user reports in assessing nonattainment of water quality standards for recreational and aesthetic uses.

II. The Department’s Previous Rationale For Declining To Assess The Available Evidence Or To List These Streams Are Not Legally Or Technically Valid

The Department rejected requests to list these waters as impaired in its 2010, 2012, and 2014 Integrated Reports, citing several technical and legal interpretations that lack merit. In September 2014 EPA approved Virginia’s 2012 Integrated Report, but expressly rejected several of the Department’s reasons for deciding not assess the evidence and make a determination as to whether these waters are attaining or not attaining the applicable water quality standards.⁷ After the Department again declined to evaluate the evidence or make an impairment determination in its 2014 Integrated Report, EPA again approved the Integrated Report, while at the same time expressly rejecting the bulk of the reasons the Department offered for taking no action.⁸

Among other things, EPA in its approval of the 2016 Integrated Report stated that “the lack of a formalized methodology by itself is not a basis for a state to avoid evaluating data or information when developing its section 303(d) list.”⁹ EPA also stated that, because “the *Virginia 2014 Assessment Guidance* does not address the types of information submitted by [Shenandoah Riverkeeper] nor provide guidance as to how citizens can submit photographs, testimonials and other similar types of data,” the “lack of a State-approved [quality assurance project plan] alone should not be used to summarily reject data or

visited Sept. 5, 2017) (in addition: “For cyanobacteria (blue-green algae), regular, reliable monitoring indicates that cyanobacteria routinely exceed guidelines established by the Vermont Department of Health for recreation. Invasive non-native aquatic species are not applicable in this category.”)

⁶ Attachment G, Montana Dept. of Environmental Quality, Assessment Methodology for Determining Wadeable Stream Impairment Due to Excess Nitrogen and Phosphorus Levels (Dec. 2011); also available online at: https://www.deq.idaho.gov/media/937622-assessment_methodology_determining_wadeable_stream_impairment_excess_nitrogen_phosphorus_levels.pdf (last visited Sept. 5, 2017).

⁷ Letter and enclosures from Jon M. Capacasa, EPA Region 3 Water Protection Division, to Melanie Davenport, Div of Water Quality Programs at , VDEQ (Sept. 23, 2014).

⁸ Letter and Enclosures from Jon Capacasa, EPA Region III Water Protection Div., to Jutta Schneider, Virginia Department of Environmental Quality (“DEQ”) Water Planning Div. at 6-8 (May 19, 2016) (“EPA 2014 Integrated Report Approval”).

⁹ 2014 Integrated Report Approval at 8.

assume that data is of low quality regardless of the actual quality controls that were employed.”¹⁰

EPA nonetheless approved the 2014 Integrated Report, reasoning that Virginia’s water quality standards present “unique challenges,” making it “challenging to identify impairments in a manner that is consistently repeatable.”¹¹ EPA’s rationale for approving Virginia’s decision not to evaluate the available evidence was entirely contrary to its own regulations, guidance, and even the rationale stated in the same approval letter. Accordingly, we have challenged EPA’s approval of the 2014 Integrated Report in the U.S. District Court for the District of Columbia (Case No. 17-1023). While that lawsuit is pending, Virginia’s legal obligations under the Clean Water Act remain the same, as EPA stated in its guidance for this Integrated Report process: “[f]or States without nutrient-related assessment methodologies, there is still a requirement to assemble and evaluate all existing and readily available water quality-related data and information against all applicable numeric and narrative [water quality standards] to develop the CWA 303(d) list.”¹²

III. The Department’s Protracted Study Of Possible Monitoring Or Assessment Methods Does Not Free Virginia From Its Duty To Evaluate Available Evidence And Make A Determination Of Attainment Or Nonattainment

For the current Integrated Report it appears that the Department is, yet again, intent on refusing to assess the available evidence of impairment, and instead relying on its ongoing efforts to develop a listing threshold or assessment method (or both) as an excuse for refusing to assess the evidence that is currently available and that shows that the recreational use and related water quality standards in the North Fork, South Fork, and main stem of the Shenandoah River are not being met due to the presence and growth of excessive algae.¹³

While we appreciate the Department’s efforts to finally take this issue seriously, and while the Department is free to propose regulations interpreting the designated use and narrative water quality standards, we note that those measures are not in currently place, and there is no legal obligation to ensure that they will be in place any time soon. In the meantime, the Department’s refusal to assess our evidence and make a determination of attainment or non-attainment is unlawful, as it frustrates and undermines the Virginia

¹⁰ *Id.* at 8-9.

¹¹ *Id.* at 7.

¹² Attachment D at 10.

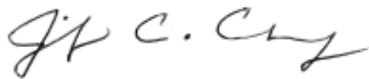
¹³ Draft 2016 Integrated Report, Chapter 4.3, River Basin Summary at 63-64; Shenandoah River Algae, Development of Field Monitoring Methods (Dec. 2, 2016), http://www.deq.virginia.gov/Portals/0/DEQ/Water/WaterQualityAssessments/ShenAlgae/VADEQ_Shenandoah_monitoring_public.pdf?ver=2016-12-02-134505-757 (last visited Sept. 5, 2017); Shenandoah River Monitoring Plan, Algal Field Methods Development (June 2016), available at http://www.deq.virginia.gov/Portals/0/DEQ/Water/WaterQualityAssessments/ShenAlgae/Shenandoah_Algal_Mo_n_Plan.pdf (last visited Sept. 5, 2017); VA DEQ Shenandoah Algae webpage on "Shenandoah Algae," <http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityAssessments/ShenandoahAlgae.aspx> (last visited Sept. 5, 2017).

Water Control Board's authority to establish the water quality standards and designated use that the Board established in 1981.

IV. Conclusion

As in prior years, we have provided material evidence demonstrating that the North Fork, South Fork, and mainstem of the Shenandoah River are impaired by excessive algal growth, and that consequently those waters are failing to support their designated use for recreation, notwithstanding the Department's ongoing efforts toward establishing a listing threshold or formal monitoring or assessment method. We therefore call on the Department to fulfill its duty under the Clean Water Act to now list the North Fork, South Fork, and mainstem of the Shenandoah River as impaired in the final 2016 Integrated Report.

Sincerely,



Jennifer C. Chavez
Staff Attorney, Earthjustice



Phillip Musegaas
Vice President, Potomac Riverkeeper Network

CC: Bill Richardson
Office of Standards, Assessment and TMDLs
U.S. EPA Region 3
Via email to Richardson.William@epa.gov

Attachment A

<u>Number</u>	<u>Description</u>	<u>Location</u>
A-1	North Fork Shenandoah River Deer Rapids, 7-25-17	38; 58; 6.4860 / 78; 22; 17.1359
A-2	North Fork Shenandoah River Deer Rapids, 7-25-17	38; 58; 16.7999 / 78; 22; 19.0979
A-3	North Fork Shenandoah River Strasburg, 7-25-17	38; 58; 18.2580 / 78; 22; 19.9020
A-4	North Fork Shenandoah River Strasburg, 7-25-17	38; 58; 29.3459 / 78; 22; 40.5779
A-5	South Fork Shenandoah River Bentonville, 7-21-17	38; 50; 36.2520 / 78; 20; 19.4699
A-6	South Fork Shenandoah River Bentonville-Purple Algae, 7-21-17	38; 50; 36.0780 / 78; 20; 19.2299
A-7	South Fork Shenandoah River Hazard Mill, 7-21-17	Hazard Mill Recreation Center
A-8	Shenandoah-Potomac Confluence, 8-24-17	Harper's Ferry, WV
A-9	Shenandoah-Potomac Confluence, 8-30-11	Harper's Ferry, WV



















**Technical Review of Evidence to Determine the Presence, Extent, and
Consequences of Excessive Algal Growths in the Shenandoah River and its
Tributaries**

**Submitted to the Virginia Department of Environmental Quality on Behalf of
Potomac Riverkeeper and Shenandoah Riverkeeper**

**David Sligh
January 30, 2015**

I. Introduction

Shenandoah Riverkeeper (“SRK” or “Riverkeeper”) has collected and analyzed a huge volume of information related to algal growths in the mainstem of the Shenandoah River and in the North and South Forks. This report presents findings and conclusions from this effort. The evidence presented, supported by hundreds of attachments and references, overwhelmingly supports the following conclusions:

- A. Excessive algal growths in the Shenandoah River, North Fork Shenandoah River, South Fork Shenandoah River, North River, and South River interfere with and sometimes prevent human uses of these streams, including but not limited to boating, swimming, wading, fishing, and aesthetic enjoyment of the environment.
- B. Excessive algal growths in the streams cited in A. damage the biological integrity and cause imbalances in aquatic communities in each stream.
- C. Excessive algal growths in the streams cited in A. constitute undesirable and nuisance plant growths in each stream.
- D. Excessive algal growths in the streams cited in A. result in the presence of floating mats of algae and decaying plant materials, color, odors, and turbidity in each of the streams.
- E. The excessive algal growths and impacts described in A. through D. occur throughout the following sections: on the Shenandoah River, from its beginning near Front Royal to its confluence with the Potomac River; on the North Fork Shenandoah River, from its beginning near Bergton to its confluence with the South Fork; on the South Fork Shenandoah River, from its beginning near Grottoes to its confluence with the North Fork; on North River, from River Mile 4 to the mouth; and on South River, from River 4 to the mouth.
- F. The excessive algal growths and impacts described in A. through D. have occurred on a persistent basis, throughout at least the period from 2007 to 2014, with variations from season to season and year to year. Impacts are most frequently observed in summer and early fall periods, when recreational users are most affected.

The succeeding sections of this document are as follows. Appendices A through H are attached

:

- II. Citizen Reports
- III. Expert Findings and Opinions
- IV. Photographs
- V. Transect Data
- VI. Water Quality Goals
- VII. Comparison of Data to Water Quality Goals
- VIII. Conclusions
- IX. References
- X. Expert Testimony - Kelble
- XI. Qualifications of David Sligh

II. Citizen Reports

Attached to this report are one hundred and twenty six (126) separate submittals from citizens describing conditions in the Shenandoah watershed and the citizens' responses to those conditions. These letters tell of algae-related problems in the River and the two Forks; many listing specific times and locations when they observed conditions caused by an overabundance of algae. Other citizen statements include observations gathered over wider time periods and larger areas and changes observed through the last several decades.

Most of the submittals are from people who use the rivers for recreational and aesthetic purposes, some of whom have done so for many years. Complaints from less frequent or newer users are also represented among the citizen statements. Those whose properties border one of the waterbodies are also well represented and have obvious economic interests that they believe to be affected by the degradation of the streams by excessive algal growths and die-off. Almost all of the commenters have long and intimate familiarity with one or more of the streams addressed and with the conditions that have been conducive to their enjoyment of activities in, on, and around the waters. Many explain in some detail the problems they have observed, the ways in which these problems interfere with their uses, and the areas and time periods affected.

A spreadsheet summarizing much of the information gleaned from the submittals is contained in Appendix A to this report and electronic versions of all of the submittals are submitted with this report. Some of the general patterns we can observe from the table in Appendix A are:

- A. Numbers of comments addressing problems on the mainstem, North Fork, and South Fork are 61, 58, and 70, respectively.
- B. Cumulatively, the complaints cite algae problems spanning the entire lengths of each of the three streams.
- C. The numbers of comments citing specific uses that were impaired includes: Fishing - 102, Primary Contact Recreation - 44, Boating - 55, Wading - 40, General Aesthetic Enjoyment - 57.
- D. The numbers of comments citing specific problems that impaired their uses includes: Periphyton, general - 31, Filamentous Algae - 55, Plankton and/or Floating Masses - 50, Color - 40, Odor - 60, Turbidity - 10, Health Concerns: Toxicity and/or pathogens - 19, Fish Lesions and Diseases - 26. Almost all commenters named more than one of the problems listed.
- E. Thirty (30) of the comments specifically compared the conditions in the Shenandoah streams with those they have experienced in other waters and noted that the conditions here were worse than those in any of the other streams they have used.

In addition to the summary of comments described above, quotes from some of the comment letters are provided below, to provide a fuller sense of the facts and opinions included in the comments. The C# notations match those that are used in Appendix A and in the file names for the individual comments. The dates on the written comments are included, next to each person's name. The specific locations discussed in these comments are spread throughout the watershed and on all three of the major streams.

Quotes from Comment Letters

C1 - Alan Lehman (9/3/14)

“In the late afternoons and early evenings on late summer and fall days, floating globs of algae nearly fill the river at my house. This discourages me and my guests from swimming in the river, since it is extremely gross when it gets on our bodies and in our hair.”

C2 - Alan Lehman (4/10/12)

“I’ve seen globs of floating algae on the back eddies and channels on the North Fork Shenandoah River in March and April of this and past years, near Woodstock, New Market, and Toms Brook. In May and June of each of the past few years, I’ve seen filamentous algae on the bottom of the North Fork near Toms Brook, and Strasburg, and also on the bottom of the South Fork near Island Ford, Elkton, Shenandoah, Luray, and on the Main Stem Shenandoah River near Morgans Ford Landing, Rt. 50 and Rt. 7 in Clarke County. I’ve seen the smelly floating algae on the North Fork in July, August, and September near New Market, Mt. Jackson, Edinburg, Woodstock, Strasburg, Toms Brook, and Riverton. This smelly floating algae is also persistent on the South Fork in late summer around Port Republic, Island Ford, Elkton, Shenandoah, Newport, Alma, Luray, and near the Andy Guest/Shenandoah River State Park in Warren County.”

C3 - Allan Thomson (4/12)

“I have noticed that there is often in the spring and summer a slimy mat of algae covering the rocks and native grasses which makes the river not only unsightly but also hazardous to walk in. This is especially true in the North fork and the main stem north of Front Royal.”

C4 - Amy Mrstik (9/16/14)

“As we approached the lower end of our trip, near Front Royal, we stopped so Rick could spend some time in an area he said looked fishy. But I noticed the area was full of dark green algae, and it smelled way worse than fishy. I didn’t want to get into the water here because of the smell, so I took pictures of some wild flowers growing along the bank. Rick waded in but soon complained that his lure was getting full of algae and his favorite fishing shirt was getting stained green. I was never able to get that gunk completely out of his shirt.”

C6 - Andrew Riccobono (4/13/12)

“I still regularly fish for smallmouth bass and panfish at the Shenandoah River Andy Guest State park near Bentonville and my experiences from spring through summer have become alarmingly predictable. . . . By July my flies are covered in green muck after every cast – whether I am fishing on the surface or with a sinking lure. When the algae die off, the decomposing clumps smell pretty nasty.”

C7 - Andrew Thayer (4/12)

“During that time on the river in April and early May, I witnessed something at the area known as Shenandoah Shores on the main stem below Front Royal. There were large clumps of green and brown stuff that were floating around. As I passed, the clumps had a sewage-like stench that could be smelled.”

C14 - Bernard Griswold (4/12/12)

“I have had riverfront property directly on the North Fork outside of Woodstock since 1991. . . . During dry low water spells, planktonic algae also increases dramatically to the point that it covers and clogs grass beds from shore to shore. . . . Fifteen years ago, vegetation in this area consisted primarily of rooted grasses which provided cover and food for a variety of river creatures, especially from mid-June through early fall. Now, beginning in early June, rooted filamentous brown algae begins to coat rocks and rubble in pools and runs and increases by mid-August to provide floating clumps of brown gunk in such quantity as to collect in masses around any object at the surface. This has resulted, in recent years, in much reduced use of the river in late summer and early fall for all our activities and provides a real eyesore from our vantage point on shore. It also provides a severe odor problem during hot dry, low water periods in late summer.”

C16 - Bill Millhouser (4/6/12)

“When these algae are blooming, the fishing is frustrating because you cannot fish without fouling your line on the algae, the fish won’t bite lures or bait with algae sticking to it. I just cannot use the River due to the odors and annoyance. I found this problem in the following areas last year from July through August: Strasburg, Bentonville, Front Royal, Luray Dam, 211, Shenandoah, Route 50, and Route 7.”

C24 - Charles V. Loudermilk, II (4/18/12)

“I have seen in recent years when on the river that the water has an odd dark greenish color that seems almost like it could glow in the dark to it in the spring. I have witnessed this just last weekend on 4-15-12 when I had floated from Rt. 50 to a takeout 4 miles downstream.”

C25 - Charles V. Loudermilk, II (8/14)

“I can recall a float from Alma to Whitehouse on the South Fork in July of 2012 that there were section of the river that the algae was so thick that that my canoe in about 2 foot of water would get stuck. I had to use my oar to push myself off the long strings of algae in these sections. I would wade Edinburg area or should I say tried to wade this area. It was very hard to even get in the water and move around because the algae were so thick.”

C31 - Douglas Lees (8/31/14)

“I fished the South Fork and Main Stem of the river this summer in July and August as follows: . . . July 20, . . . on the South Fork near Luray, catching no bass and no sunfish and noticing numerous clumps of foul-smelling algae—this section of the river smelled like an outhouse.”

C41 - Elwyn “Chip” Comstock (4/10/12)

“The places I like to wade and fish are mile 13, 16 and up stream from Andy Guest Park. The past two years I’ve fished these locations less due to the fact that I not only find algae as mentioned above but I find fish that have abnormal growths on them. I typically fish these areas from May through September; however, I’ve begun seeking out other locations due to the poor conditions of the water.”

C63 - Jeff Browne (8/25/14)

“Last week I was paddling up-river from the Hazard Mill landing in Bentonville (Hazard Ford Road) and for the first quarter mile you can see the devastation caused by algae as the river grass has been killed over time. The largest smallmouth bass I’ve caught on the river have been in that stretch, but no more. Now I just paddle through it in order to get to faster waters that haven’t been hit as hard.”

C64 - Jeff Little (4/9/12)

“The last time I visited the Shenandoah River to fish was last September near Pugh’s Run on the North Fork I took my two sons to wade and fish where I have fond memories of catching feisty smallmouth bass. We spent about t}rte hours wading downstream, catching a few small bass, a far cry from my memories of this previously impressive fishery. The slippery filamentous algae that permeated the river bottom made wading treacherous for my sons. The "snot grass" coated their water sandals and when the decided to jump in further;, the rest of their clothes. It also made for frustrating fishing as each cast yielded a crop of algae that prevented our catching many fish.”

C68 John F. Ehrlich (4/6/12)

“Finally in 2008, I decided to visit the low water bridge at Bentonville to see if the river quality had improved since I last fished here. . . . It was during a particularly hot period in July. I was shocked to see the amount of algae both upstream and downstream from the bridge. The slime that clung to the rocks was clearly evident and the noxious odors that I first noticed in the 1990s had become worse . It is a sad epitaph for a river that so many considered one of the premier rivers in the Mid Atlantic.”

C69 - John Holmes (8/27/14)

“I have a cottage on the North Fork near Woodstock Virginia and my sole reason for choosing this location was to have access to the river and the ability to enjoy the river.

. . .

I want to share a specific problem that occurred this year. In early July we had some heavy rain that washed out some of the algae that had been accumulating. I was at the cottage on the weekend of July 12th and was able to wade and fish. With that good experience I invited my partner's family of five ... two adults and three boys ... to come out the following weekend of July 19th and 20th. We and they had planned to canoe, fish, and swim. When we got to the cottage, we found the algae was back with vengeance. The swimming and tube floating were cancelled. We fished a little from the low water bridge but could not wade fish. Clumps of algae in the slow water near the bridge made it a stinky environment. The older boys asked what was wrong with the river, when they smelled the algae and saw the slimy floating clumps during a brief canoe trip.”

C80 - Leslie D. Mitchell (4/12/12)

“I am a volunteer water monitor for Friends of the North Fork of the Shenandoah River, so I observe the portions of the North Fork near Strasburg on a bimonthly basis. . . . In recent years, I have noticed or been alerted to numerous and different types of algae blooms and observed thick algae growth on the river’s surface and below the surface. The blooms I have observed have been in the summer and early fall of the year. Please see photos below of an algae blooms: 1) June 22,

2010 about a mile downstream of Deer Rapids Bridge; 2) Same location and date; 3) and 4) Bloom that occurred in the North Fork between Deer Rapids south of Strasburg and the Rt. 55 Bridge across the North Fork, northeast of Strasburg in July of 2011. The algae smells bad, is difficult to paddle through and creates an unpleasant recreational experience in general, especially as it causes one to wonder what it is that is causing these imbalances in the water, allowing this unusual algae growth to occur.”

C81- Mark J. Frondorf (4/13/12)

“This past summer, I donated my time as a fishing guide to the Shenandoah River Rodeo that took place in Front Royal, VA. I was embarrassed to take major contributors out on the supposed crown jewel of Virginia rivers as rock snot coated every rock and eddy pocket on the river.”

C82 - Mark R. Myers (4/5/12)

“When my wife and I were dating in the 1980s we found several locations along the North Fork of the Shenandoah in the Strasburg area where we would picnic, wade and fish. For a number of years we occasionally returned to these spots, such as the VA Rt. 55 crossing. When we visited that area in the summer of 2011, the river bottom and water conditions were drastically changed from a decade earlier. There was abundant ‘snot weed’ and a lack of grasses that were previously in the river. The river bottom was not visible and what was previously an attractive river for wading was not at all inviting. What should have been a pleasant outing remembering good times from earlier years turned out to be very disappointing and left us concerned that future generations will not realize what a lovely resource the Shenandoah one was.”

C91 - Preston Lazer (8/27/14)

“I was both embarrassed and disgusted back in mid July when I took a guest for a first trip on the section of the South Fork from Karo Rapids to Front Royal landing. I thought this would be a great chance to show what a gem Virginia has! Instead, what I had talked up as "one of the top things to do in Virginia" turned into bewilderment at what had happened to our river. For much of the trip, it was just an exercise in frustration to fish because every time we retrieved a fly, it was covered in algae snot. Also, the stench was overpowering at times. . . . I am sorry to say that when one of my friends called to ask for advice on unique things to do in Virginia with his visitors from Denmark, I told them to go visit the New River in West Virginia rather than to float the Shenandoah so they don't embarrass themselves like I did.”

C97 - Robert Forbes (9/17/14)

“After one South Fork fishing trip in July, 2014, when I got in my car, I noticed an overpowering odor of rotting material and thought the odor must have come from something decaying in my car. Then I realized the odor came from my shorts that had been immersed in the Shenandoah River while I was fishing!”

C99 - Rodney Miner (8/27/14)

“My most recent outing was July 12th when I floated and fished from Island Ford to Elkton. My friend and I saw lots of algae and the fishing was absolutely terrible. We saw dead fish lying on the bottom of the river and caught very few fish which is very unusual on this stretch of river. I caught two smallmouth bass with lesions on their sides. . . . I had planned to float the river

numerous times this summer but, when one sees these conditions you have to wonder how healthy it is to be in water when you see high levels of algae and dead fish.”

C103 & 104 - Stan Ikonen (8/23/14 & 4/12)

“My group of two canoeists and one kayaker encountered a fairly significant bloom just last Sunday, 8/17, on the same stretch [the main stem of the Shenandoah between Shepherds Ford and the bridge at Rt 7. It was nasty enough that our teenaged female guest asked that we get out of the river as she was not comfortable with the floating algae. We stopped about halfway through our float. I hitched a ride to the takeout point to retrieve my truck and a nice day was ruined as the result of the algae in the water.”

“Last June I canoed the South Fork of the Shenandoah from Bentonville to Front Royal with a group of friends. It was one of the most unpleasant experiences of the year. Worse than the record-breaking heat was the appearance, smell, and an almost slimy feeling of the water. It was disgusting. We stayed overnight on a sand bar. I usually take a swim before I bed down to remove the day’s dirt and sweat. Not that night. I choose not to expose myself to the water anymore than needed.”

C107 - Steven R. Adams (9/7/14)

“Just this past July 2014, on a float trip on the South Fork of the Shenandoah River, from Alma to White House near Luray, I encountered numerous stretches of the south fork with large amounts of algae. The algae smelled like something was rotting, it was slimy, and stuck to everything on my kayak and fishing gear. The algae also made the bottom very slippery and dangerous in places. Just trying to get in and out of my kayak was problematic.”

III. Expert Observations and Opinions

In addition to experience as river users, 9 of the commenters listed in Appendix A have expertise in areas pertinent to the issues addressed in this report. The first group has extensive professional experience and expertise in fishing and river recreation and in the preferences of stream users. The second has expertise in water quality science, pollution investigations, water monitoring, and comparison of data to water goals.

Fishing and River Recreation Experts - The following listed commenters have many years of experience in outfitting and guiding fishermen and boaters on the Shenandoah watershed streams and on other waters.

C21 - Brian Trow

C26 - Colby Trow

C58 - Jacob Russo

C78 - L.E. Rhodes

C100 - Ron Evans

C102 - Scott Osborne

C114 - Trace Noel

Section X of this Report - Jeff Kelble

Because their livelihoods have depended on knowledge of the natural conditions in these streams, as those conditions relate to fishing success and the enjoyment of their clients, the expert opinions of these persons must receive extra weight regarding the streams' abilities to meet certain water quality goals.

They are qualified to give expert testimony about objective questions regarding the presence or absence of color, turbidity, floating materials, the extent of algal growths, odors, and the integrity and balance of the ecosystems in which they have worked. Subjective questions regarding the levels of algal cover and extent of other effects which rise to the level of nuisance or undesirable conditions and which have and/or will impair clients' enjoyment of their experiences are also within their areas of special expertise. As stated by Kelble (Section X):

What is MOST IMPORTANT about my life's fishing history and my professional career as a fishing guide was the fact that I made a living selecting the very best body of water in the Mid-Atlantic to take people fishing. This required that I have access to multiple sections of river, on multiple rivers in multiple states. My reputation and my success hinged on my ability to evaluate the physical conditions of the river including flow, water clarity and seasonal movements of fish to determine where I would take my clients through the ten month full-time season. (underlining added)

Included below are some quotes from these experts' comments that are especially pertinent to the degrees to which the Shenandoah and the North and South Forks provide pleasurable conditions for recreationists and the effects of algae on those experiences:

C21 - Brian Trow

“Half of the beauty of floating the rivers of our state is underwater. Looking into a river and seeing nothing but green water, brown and green rocks, and smelling the awful smells of rotting algae is very discouraging. We already have to deal with poor water quality that takes trophy bass from us every year, and now we can't even enjoy the beauty of looking into the river. . . . I guide and fish on many other rivers in the state including the James in central Virginia, The Rappahannock, the Cowpasture, and the New. All of these drainages have algae, but not nearly to the degree that the Shenandoah does.”

C26 - Colby Trow

“We are on the river 12 months a year and almost daily in the spring and summer. We have 7 boats and run more float fishing trips on this river than any other fishing guide service. We do target the James River and New River for smallmouth bass and musky, however we consider the Shenandoah River our home water. Unfortunately claiming the Shenandoah our home water is becoming more and more embarrassing each year as we see constant algae blooms, fish kills, disease, foul smelling water, experience waterborne infections, and more. Some of our guests will not return to fish the Shenandoah or our area again as a result of what they see on the water.”

C58 - Jacob Russo

“I fish and guide on the North Fork, South Fork and Main Stem of the Shenandoah. However, for much of the year, large sections of each river seems to experience a series of noxious algae blooms that seriously diminish my use and enjoyment of the rivers. . . . Over the course of the year I use the entire river system and have seen this on all three rivers from Port Republic down to Front Royal, from Broadway to Front Royal and from Front Royal to the Confluence with the Potomac River. This bloom turns the river a dark murky green color, like green paint, from late winter until about July. When the algae blooms I often choose not to swim or fish. When I do fish I find the fishing is poor and I don't enjoy the experience as much. Whenever the river is this murky color, it's disturbing to fish and the fish are usually lethargic and often they don't feed at all. Activity in the river drops to near zero.”

C78 - L.E. Rhodes

“Over the years I have enjoyed spending time with family and friends as well as customers on the river. The algae problem has gotten bad enough that I am hesitant to take trips during the time of the algae blooms. It has a musky smell that takes the pleasure out of what would have been a great day on the water. Plus when fishing it is forever fouling in your hooks. I refuse to allow anyone to get in the water to wade or swim.”

C102 - Scott Osborne

“I use the river extensively throughout the spring, summer and fall months for recreational fishing as well as professionally guided fly fishing services. Typically, I use the river 2-4 times a week during these months as flows allow for successful navigation of the river. . . . There have been numerous days that my clients were relatively disgusted by the incredible amounts of algae in the river and all of us knew it was the culprit for the slow day of fishing as well as the terrible smell. They did not even want to get in the river to cool off on the hottest of days. . . . I have fished all over the world, and the Shenandoah is one of my favorite, but only when it is not choked by algae.”

C114 - Trace Noel

“As a retired outfitter on the South Fork of the Shenandoah with more than 20 years of daily and first hand experience I can speak directly to the impact that both phases of the algal bloom has on the river. . . . During the Spring and Summer large clots of algae break loose and head downstream. Resembling tumbling and floating human waste, these algal turds gross out urban guests, exasperate anglers, collect in slow moving water and leave a vomitus stench that diminish the experience by both private landowner and thousands recreational users. . . . The impact to the watersport recreation industry in the Shenandoah Valley – read economic loss to struggling rural communities - is substantial From float tubers to anglers with tangled lines our operation suffered diminished participation from urban guests who chose other ways to spent discretionary income.”

The most detailed comments from an expert in the field of river recreation and fisheries come from Jeff Kelble (labeled C120 in Appendix A). Kelble’s testimony is at Section X. of this report.

Water Quality Expert

The author of this report submits this document, attachments, and appendices as expert testimony on the matters addressed herein and has included information, including a resume, to support his status as an expert in the fields of water quality assessments, stream ecology, and pollution impacts.

Agencies

Because resource agency personnel have special expertise in the issues examined in this report, we cite two examples of agency opinions that bear on our assertions.

Virginia Department of Game and Inland Fisheries (“VDGIF”) - On its web site, the VDGIF provides descriptions of certain segments of Virginia streams and of the fishing opportunities in these locations. One item on the web site reads as follows:

*The North Fork is a relatively small, shallow river and is very accessible to wade angling. **Excessive nutrients in the watershed promote the growth of algae and aquatic plants. The vegetation can become very dense during the summer/fall months and impede fishing and boating.** (VDGIF 2014)(emphasis added)*

Virginia Department of Environmental Quality - In response to a citizen who reported the possible dumping of cow manure in the North Fork Shenandoah River, Don Kain, Water Monitoring and Assessment Manager in DEQ’s Valley Regional Office investigated and responded to the complainant, in part, as follows:

*I just returned from the river. The material in your photo was indeed still there. . . . **based on the appearance and odor (both definitely nasty), I think what we are seeing is decaying blue-green algae mats.** I took a trip down the river 2 weeks ago from Deer Rapids to Strasburg with Jeff Kelble specifically to evaluate nuisance algae problems. The material at Black Bear crossing looks the same as the mats we observed on that section of the river. . . . **By the way, these blue-green algae mats are quite often mistaken for sewage, due to both appearance and odor.**” (Kain 2012) (emphasis added)*

IV. Photographs

Attached to this report are more than 1,000 photographs and 15 videos. These pictures show a great variety of different kinds of excessive algal growth, including planktonic species, algae attached to substrates and to vascular plants, and floating algal mats and decaying materials. The photos and videos are listed in Appendix B. Each has a designated number (A1, A2, etc.) and in almost all cases is identified by date, stream, and river mile. Through the photographers, the photos can be verified to be true representations of the actual conditions at the sites and times named. The electronic records for each photo shows that the images have not been altered. All of the photos and videos are included as attachments to this report.

Below are examples of certain types of conditions depicted by the photographs. The significance of these views in relation to water quality goals is discussed in Section VII below.

Highly Colored Waters

As described in citizen comments, at times stream segments in the Shenandoah and major tributaries appear to have a bright or dark green color throughout the water column - “like green paint,” according to numerous witnesses. Examples of such conditions are shown in Figures 1 - 8. These eight photographs range in time from 2007 through 2014 and represent widespread segments from each of the three streams cover in this report.

Floating Materials

Figures 9 - 15 show scenes of floating masses in the streams, including algae and other plant-related materials, some in different stages of decomposition. Again, the photos range from 2007 to 2014. Most of these Figures are taken from those on the North Fork Shenandoah to show the wide array of appearances that occur in this one stream. Additional examples of floating materials in a variety of forms are shown in photos of the South Fork Shenandoah, which can be found in the attachments to this report, at: photos A659 (river mile 92), A634 (river mile 70), A595 (river mile 38), and A573 (river mile 18). Likewise, photos in the attachments show portions of the mainstem Shenandoah River with various forms of plant-related floating matter at: A453 (river mile 39) and A454 (river mile 38).

Stream Bottom Coverage

Many of the photographs attached to this report show benthic algal growths in the Shenandoah River and its tributaries. These photos show a variety of types of algae that are attached to bottom substrates, from filamentous forms to various low-growing brown and green forms that coat the rocks. Attached form of blue-green algae are present in very substantial amounts and in a wide range of locations. Figures 16 - 21 show the variety of forms and the density and extent of these growths at a number of sites. Overall, the photographs submitted with this report show hundreds of views of excessive algal growth spread throughout the lengths of the North and South Forks of the Shenandoah and on the mainstem. While still photographs are only capable of showing limited fields of visions, the videos show that the algae covering certain portions of the stream bottoms stretch over long distances.

In combination with the pictures and videos taken on these streams, from above and below the surface of the water, SRK submits many more aerial photographs which also show heavy growths at virtually every one of the hundreds of miles of streams photographed.

Algae and Vascular Plants

In some areas in the Shenandoah streams there have historically been healthy growths of underwater grasses and other vascular plants. In Figures 22 through 24 are photos of heavy algal growths on the surface of these vascular plants and throughout these plant beds. In some cases, it is evident from the photographs that dead and dying vascular plants have been covered by algal growths.

More discussion of this issue is presented in Sections VII.F. and X.

V. Transect Data

During 2012, personnel working with Riverkeeper conducted a systematic study to characterize stream bottom conditions in the Shenandoah River, the North and South Forks of the Shenandoah, South River and North River. This study revealed extremely high substrate coverage by periphytic algae in many areas during the months of June and July of 2012. These data are representative of patterns throughout stream segments where the transects were sampled and, given similarities in environmental conditions and observations between these segments and larger segments of the streams represented, are arguably indicative of the wider stream conditions.

The SRK researchers used a square frame of fixed area (see photograph A1027) at every sampling point and placed this frame at, generally, ten evenly distributed locations across a stream transect. They visually assessed the percent coverage of attached algae within the frame at each sampling point. The exceptions to the sampling of tens sites were made when, for example, the water depth prohibited sampling at a particular spot on a certain occasion. For each of the stream segments, which ranged in length from 3 - 6 river miles and wherever possible, given physical conditions, divided into transects 0.25 miles apart.

This method of transect sampling is similar to ones outlined in documents such as the Stream Periphyton Monitoring Manual (Biggs and Kilroy 2000) (See also: . The transect sampling program fits into the category described as a resource survey, which is designed to “establish general patterns of periphyton biomass and composition in time and/or space. Such data can then be used for desk-top assessments in discussions of possible changes to water resources/landuse management regimes, classification of waterways according to degree or type of human impact, etc.”

Because the primary objective of this sampling was to see whether algae growths would qualify as nuisances or be termed “undesirable” by recreational river users, many of the aspects that might be important for other studies of benthic algae were not needed in this case. For example, while taxonomic descriptions of the types of algae present would certainly be necessary to meet the objectives of some studies, such information would be of little use here. The SRK study aimed to determine the overall nature and percent coverage of stream transects and the use of general descriptive terms such as “filamentous” or “thick mat” and notations of the color of algae, as contained in the monitoring reports (Appendix C), are fully sufficient.

Biggs and Kilroy (2000) list transect sampling under what they term as “rapid assessment protocols” and note that some such programs are “specifically designed for assessing compliance with the periphyton guidelines for cover to protect aesthetic, recreational and fishing values.” (citing: Biggs 2000a). The following description of “rapid assessment protocol 1” by Biggs and Kilroy (2000) is a relatively accurate description of the methods used in the SRK study:

This method involves setting up transects across a site and recording the percentage cover of filamentous algae > 3 cm in length for a given number of quadrat points. Percentage cover values for the individual points are then averaged to obtain an estimate of the average cover of the site by

filamentous green/brown algae. These individual records can also be used to later construct a map of the distribution of filamentous algae and, if repeated sampling is performed, then changes in the distribution of mats or patches of these algae can be traced over time. Such analyses, if combined with some physical measurements (e.g., shading, water velocities, depths and/or substrate composition), can provide useful insights into the primary factors controlling the local development of proliferations.

Aside from limiting the types of algae to filamentous forms of > 3 cm in length, the SRK program is entirely consistent with that described.

Figures 25, 26, and 27 show locations of the stream segments where the sampled transects are located within the Shenandoah River watershed. Researchers sampled three segments on the South Fork and two on the North Fork of the Shenandoah. The North Fork segments covered areas within river miles 11 - 17 and 83 - 86. The South Fork segments covered areas within river miles 18 - 21, 32 - 37, and 75 - 80. For the mainstem Shenandoah one segment stretching from river mile 22 to river mile 27 was monitored and for the North and South Rivers the segments covered river miles 0 - 4 and 1 - 4, respectively.

The results of the transect surveys are contained in Appendix C to this report and Appendix D shows spatial representations of the algal % cover results. Table 1 shows the mean values for percent cover by benthic algae for each stream segment and date monitored.

The results show particularly high mean values on the most upstream segment on the North Fork [NF RMs 83-87], with values of 31% and 35.1% algal coverage for all transects in late June and early July of 2012, respectively. Figure 28 shows a representation of these observations and reveals that, of nine transects where algal cover was measured in the July 12, 2012 sample run, almost all transects had very high percent cover across 60 - 100% of the stream's width. For transect 3, all measurements showed at least 70% coverage.

Table 1 also shows that in at least one sampling period for each segment, two areas on the South Fork [RMs 18-21 and 32-37] had especially high mean values. Likewise, the segment near the mouth of South River had an overall mean coverage of 30.8% on June 16, 2012.

While these mean values are of some value in characterizing conditions in these streams at certain times, more detailed views of the distributions of results are required, because mean calculations are not fully appropriate for situations like those we are trying to represent here. Mean values are most useful in understanding the nature of a sample population where the data are normally distributed, however the variability in stream substrates and other factors that affect plant growth in streams causes an inherent "patchiness" in distribution and a large degree of variability through time.

As explained by Hynes (1966):

A notable feature of plant communities is that they do not occur everywhere; there are nearly always bare areas due to scour, periodic drought or other factors, and the individual patches of plants expand and contract and move around. . . . This sort of impermanence is one of the

reasons for the rapid and often spectacular changes shown by the plant communities of running water. Undoubtedly the general stability of the river bed and the amount of fluctuation in current play and important part in the life of river weeds. . . . The algal community of rivers is essentially sessile, it grows on solid bodies and can develop only where these are present; in places where the substratum is soft mud it can grow only on weeds or hard parts of the bank.

As explained by Biggs and Kilroy 2000, “the degree to which our ‘sample’ represents the ‘whole’ of what we are interested in is a function of the number of samples we take in relation to the degree of variability (or patchiness) of communities or populations.” To gain a true picture of the effects of algal growth on the Shenandoah streams, a more detailed examination of growth patterns than that which can be gained by looking at averages for entire segments is necessary.

For example, while the overall percent coverage in the most upstream segment in the South Fork on July 17, 2012 was only 18.1%, Figure 29 shows that certain transects within that segment had extraordinarily high degrees of bottom growth. Transect 6 has coverages of from 50 - 90% in 9 of the 10 samples taken that day, for an average of 63% coverage in this section of the stream. Also, in the North Fork on June 29, 2012, the overall percent coverage is 21.1% but in a number of the transects coverage was much higher (Figure 30).

Table 1

<u>Stream Segment</u>	<u>Date</u>	<u>Segment Mean % Cover</u>
Shenandoah R. [MS RMs 22-27]	June 20, 2012	2.9
“ “	July 11, 2012	6.5
“ “	July 25, 2012	2.5
North Fork Shen. [NF RMs 11-17]	June 15, 2012	23.2
“ “	June 29, 2012	21.9
“ “	July 16, 2012	25.2
North Fork Shen. [NF RMs 83-86]	June 26, 2012	31.0
“ “	July 12, 2012	35.1
“ “	July 26, 2012	0.4
South Fork Shen. [SF RMs 18-21]	June 21, 2012	39.0
“ “	July 10, 2012	13.0
South Fork Shen. [SF RMs 32-37]	June 14, 2012	42.2
“ “	June 27, 2012	10.5
“ “	July 15, 2012	11.5
South Fork Shen. [SF RMs 75-80]	June 13, 2012	4.1
“ “	June 28, 2012	10.2
“ “	July 17, 2012	18.2
North River [NR RMs 0-4]	June 23, 2012	15.1
“ “	July 9, 2012	11.5
“ “	July 23, 2012	9.3
South River [SR RMs 1-4]	June 16, 2012	30.8
“ “	July 2, 2012	16.7
“ “	July 14, 2012	4.1

VI. Water Quality Goals

The water quality requirements set by the Clean Water Act (“CWA” or “the Act”), though necessarily interpreted in legal contexts, also reflect qualities by which scientists routinely judge the health of water bodies. Though terms used in the scientific literature may differ in some aspects from those used in the law, the concepts behind the terms used in the Act are consistent with those used by water quality scientists and ecologists.

Congress stated that the Act’s objective is “to restore and maintain the chemical, physical, and biological integrity of the Nation’s waters.” This focus on the “integrity” of water bodies emphasizes the fact that for environments to be truly functional and sustainable they must be maintained so they continue to work as integrated systems. Those systems that most closely approximate “un-impacted” conditions (where there has been very little or no anthropogenic disturbance) are likely to have the highest levels of integrity. Biological integrity, for example, has been defined as “the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region” (Karr and Dudley 1981).

The CWA also requires that uses, both human and ecological, must be fully supported and sustained to fulfill the law’s purposes. As one authority has stated, “drawing a sharp line between the human and natural realms serves no purpose when our imprint is as ancient as it is pervasive” (Western 2001). Humans have evolved alongside natural features such as streams and can use streams to supply basic as well as recreational and aesthetic needs in ways that do not destroy the basic nature and structure of the systems. A healthy ecosystem will support reasonable, beneficial human uses and the impairment of such uses indicates that the integrity of that system is also likely to be impaired (Carlisle et al. 2013).

In sum, if a stream doesn’t fulfill its purposes - as a sustainable home for plants and animals; a resilient whole, designed by time and ever-evolving to handle natural changes; and a resource suitable for beneficial human uses - then it lacks those characteristics that make it a “healthy” body of water. Virginia’s water quality standards contain both narrative statements and, for some parameters, numeric measures of required quality. In this report we compare the narrative guidelines in the standards to conditions in Shenandoah River watershed streams and, thereby, decide whether these streams meet the kinds of technical measures that make them “healthy” streams.

The foundation of water quality standards is the designation of reasonable and beneficial uses, including the maintenance of healthy communities of plants and animals, that must be possible in each water body. Where necessary to support those uses, officials must develop specific measurable “criteria” to make it easier to know when there’s a problem but, regardless of such technical analyses, the bottom line is the same - that the streams still be useable for reasonable purposes. The criteria must be measurable in some way (either quantitatively or qualitatively - or usually both) to be meaningful. Both types evidence are routinely and necessarily collected and used by scientists to assess water body health and each is fully valid, when applied in the correct context.

Virginia's water quality standards regulation contains a number of requirements that are pertinent to our study of excessive algal growth in the Shenandoah River system.

A. **Uses designated for all streams in Virginia include:** “**recreational uses**, e.g., swimming and boating; **the propagation and growth of a balanced, indigenous population of aquatic life**, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish.” 9VAC25-260-10 (emphasis added).

B. “**State waters . . . shall be free from substances** attributable to sewage, industrial waste, or other waste **in concentrations, amounts, or combinations which** contravene established standards or **interfere directly or indirectly with designated uses of such water** or which are inimical or harmful to human, animal, plant, or aquatic life.” 9VAC25-260-20.A. (emphasis added).

C. “**Specific substances to be controlled include**, but are not limited to: floating debris, oil, scum, and other **floating materials**; toxic substances (including those which bioaccumulate); **substances that produce color**, tastes, turbidity, **odors**, or settle to form sludge deposits; **and substances which nourish undesirable or nuisance aquatic plant life.**” 9VAC25-260-20.A. (emphasis added).

D. “All surface waters of the Commonwealth shall be provided” a level of protection which maintains and protects “existing instream water uses and the level of water quality necessary to protect the existing uses.” 9VAC25-260-30.A.1. (emphasis added).

To make a technical determination as to whether Shenandoah watershed streams meet these required levels of quality, the following questions are answered in this report.

- ◆Do these waters exhibit unnatural colors?
- ◆Do these waters exhibit unnatural odors?
- ◆Are there unusual floating materials present in these waters?
- ◆Are there forms of undesirable or nuisance plant growths in these waters?
- ◆Does the quality of these waters interfere with the recreational uses, including aesthetic enjoyment?
- ◆ Does the quality of these waters interfere with the maintenance of balanced, healthy aquatic communities?

VII. Comparison of Data to Water Quality Goals

The following sections A. through F. discuss the evidence of conditions occurring in Shenandoah valley streams, to answer each of the questions posed in Section VI. After the individual categories are addressed, the temporal and areal coverage of conditions is described.

In discussing its response to citizen complaints regarding excessive algae growth in the Shenandoah in 2012, the Virginia Department of Environmental Quality (“DEQ”) has stated its views as to the nature of data that will be sufficient to determine whether a water quality impairment exists or not (VADEQ 2014b):

Waters that do not meet Water Quality Standards due to a pollutant(s) may be listed as impaired. “Pollutant” is defined in Federal law and either narrative or numeric water quality standards may be used to list waters as impaired. However, an “impaired” designation can only be made based on specific and objective monitoring data, in terms of location, extent, and duration, as well as an accepted, scientifically valid assessment method that compares monitoring data to water quality standards or criteria.

While this statement acknowledges that violation of narrative standards may qualify a water body for an “impaired” designation, the Department’s approach to the data citizens have submitted for excess algal growths seems to betray an unwillingness to do so. The assertion that “objective monitoring data” is required, when there are subjective aspects to the criteria in the WQS regulation, substitutes the staff’s judgement for that of the State Water Control Board, the body empowered to establish these regulatory requirements. This failure to take the narrative requirements seriously is especially problematic, since the DEQ has so far refused to adopt the kind of objective (numeric) criteria they claim are necessary to control nutrients and algal problems.

Further, the Department’s stance, that citizen observations of stream features that are readily and accurately assessed by human senses fail as “scientifically valid assessment method(s),” is simply technically and practically wrong. The agency derogates public comments as “largely anecdotal,” despite the fact that many of those comments include specific descriptions of the problems encountered and the ways those problems interfered with human uses (and in some cases aquatic life uses—such as algal growths covering and replacing vascular plant beds).

In many cases, including a number of those quoted in this report, the citizens name exact locations where they’ve observed problems. (e.g.: C1 - “floating globs of algae nearly fill the river at my house,” C68 - “slime that clung to the rocks was clearly evident and . . . noxious odors” at “the low water bridge at Bentonville”). In many other cases comments name a particular stretch that is commonly traversed by boaters and describe conditions with a significant degree of detail. Some commenters cite exact dates (see e.g.: C24 - “water [that] has an odd dark greenish color that seems almost like it could glow in the dark . . . on 4-15-12,” C69 - the “weekend of July 19th and 20th [2014] . . . smelled the algae and saw the slimy floating clumps”), while others described longer periods of time within which they had observed algae nuisances on numerous occasions. Finally, some to the people who submitted testimony cited and quoted from the detailed fishing logs they maintain, in a demonstration of systematic data gathering (e.g.: C47).

While these types of citizen reports might be dismissed as merely anecdotal if there were only one or several of them and the commenters attempted to claim a specific sighting represented the conditions of entire streams, such is not the case here. Along with dozens of descriptions of specific problems at specific places and times, the statements include those by river users who describe long-term observations and are able to describe changes over time in some detail. Further, as noted above, the observations were primarily statements of fact, not assertions that commenters' scattered perceptions qualified them to make scientific conclusions for which they are unqualified.

It is very important to recognize that the type of monitoring that is most appropriate for any situation is determined by the nature of the subject under study and the degrees of precision necessary to make valid and usable findings. Virginia DEQ officials seem to assert that only persons with scientific training in the use of specialized equipment, in sampling of water, sediments, or fish, or in the conduct of benthic macroinvertebrate studies may contribute useful and necessary information for use in determining the quality and status of waterbodies. This position is not supportable.

Visual assessments of water bodies are used by all scientists, including those at the DEQ, and often provide data that are as or more important than the concentrations of pollutants or taxonomic identifications. As rightly noted by the DEQ, and as confirmed by the author's experience, when identifying the cause of a fish kill, "notations on conditions at a kill site and the affected species may often be as helpful to the diagnostician as samples sent to the lab." (VA DEQ 2002). The exact types of data that are pertinent to assess compliance with most the narrative criteria are ones that any water user can provide.

The existence of unusual color, odor, or floating materials in a stream do not require special expertise and the testimony of dozens of people, many who have frequented these streams for decades and with great frequency, is sound evidence of these conditions. Whether these same river users have avoided use of these waters or have had their uses impaired is a question that only they can answer. Whether algal growths are undesirable or reach "nuisance" levels are subjective questions but the evidence shows that there is close agreement amongst citizens of various regions who have been surveyed, authors in the scientific literature, regulators in other states and nations - and the dozens of frequent Shenandoah River users who have given their opinions to the DEQ.

The one question that does require scientific expertise to determine whether a portion of the water quality goals is violated, is whether "the quality of these waters interfere with the maintenance of balanced, healthy aquatic communities." Lay observations are of value here even here, especially when made systematically, but must be interpreted, along with other data, by experts before sound conclusions can be made. That recreational users' observations can be valid sources of information upon which to base scientific findings is clearly demonstrated by the common use of creel surveys by fisheries experts or census reports from birdwatchers by avian researchers.

As explained below, an examination of the evidence available to the State of Virginia in 2012, in light of the scientific literature on the nature of streams that exhibit the kinds of growth

described, supported a positive response to the question about the biological integrity of these streams as well as the other questions posed. There is no evidence, however, in the public record that the DEQ conducted such an analysis.

Over two-thirds of the comments accompanying this report were also submitted to the DEQ for consideration in the 2012 Integrated Report's preparation. As discussed in regard to each of the subject areas below in this Section, those reports were fully adequate to assess compliance with all but one of the water quality goals we identified in Section VI.

Because the evidence provided in 2012 supported designation of the Shenandoah River and its tributaries as "impaired" in 2012, the Department's failure to do so then and EPA's failure to override Virginia's decision are not supported by the technical record. Despite the fact that the citizen testimony should have met the threshold test for designation as "impaired" for recreational and aesthetic uses and should meet it even more strongly now, with additional statements in the record, SRK decided to provide the additional and extensive evidence contained in and submitted with this report. The expert opinions, photographs, videos, and results of transect analyses only amplify and make even more overwhelming the scientific and technical case, proving that excessive algal growths cause violation of at least six separate provisions of the Virginia WQS regulations.

The determinations for each of the conditions examined below depend on either objective or subjective evidence. Of course, scientists depend heavily on objective standards to assess the quality of streams and in almost all of the categories discussed here there are measurable, reproducible methods for making these determinations. Only in one of the categories, whether excessive plant growths produce "undesirable" or "nuisance" conditions, are subjective standards used. Even in this category, however, scientists routinely make such determinations, as demonstrated by the published literature.

This kind of common understanding and definition of terms displayed by water quality experts, even on matters where precise measurements may not be easily made, is not only possible - it is common. While any one individual's perceptions of what is undesirable or is a nuisance is subjective, the opinions of a group of people, such as water quality scientists, who are very familiar with a range of situations and who regularly exchange information and opinions within their field of expertise can be relied upon and used to make substantive decisions as to when problems exist and action is needed to address them.

Water pollution experts have recognized for more than fifty years that subjective terms were necessary to the definition of problems and protection of our water bodies. In the foundational 1963 work, "Water Quality Criteria," McKee and Wolf (1963) defined parameters used to determine when certain human uses were supported. Among their definitions:

To be acceptable to the public and the regulatory authorities, waters that are used for swimming and bathing . . . must be esthetically enjoyable, i.e., free from obnoxious floating and suspended substances, objectionable color, and foul odors. . . .

Conditions of water quality that affect boating and esthetic enjoyment are . . . heavy growths of attached plants or animals; blooms or high concentrations of plankton; discoloration or excessive turbidity . . .

McKee and Wolf (1963) also offer descriptions of the ways that so-called “inferential” or “circumstantial” information from citizens has historically been valued in making important decisions about water quality. When “non-technical” assessments are credible and pertinent, judges and citizen juries have often valued the opinions of “non-technical” people in such cases. One such case from 1937 is especially pertinent to the kinds of problems faced in the Shenandoah. As recounted by McKee and Wolf (1963):

In *Albough v. Mt. Shasta Power Corporations* (1937) 9 Cal. (2d) 751, 73 Pac (2d) 217, the circumstantial evidence of the growth of weeds, the foul odor that emanated from a pool, and the preferences of cattle and horses for other bodies of water were sufficient to cause the jury to conclude that the water was in fact polluted.

As to the effects of these changes in condition of the water body, the California Supreme Court, as quoted in McKee and Wolf (1963), noted that “[t]wo chemists were produced who testified that from a chemical analysis the water in the pool was fit to drink” but the Court also observed that “[v]arious witnesses for respondents testified as to the preference of cattle and horses for other fresh and nonstagnant water” and “[s]everal witnesses living on the pool testified that in the years since the diversion they have never seen cattle drink from the pool.” The Court upheld the juries factual interpretation of the evidence.

Thus, as to matters of fact about whether real conditions in a water body in fact caused users (in this case cattle and horses) to avoid using the water for beneficial and desirable purposes, the subjective opinions of the users (the animals) as manifested in their behavior was determinative for the jury. That the Court upheld the factual findings of the jury in this case over the chemical evidence is not a rejection of sound, scientific methods. This decision simply shows that both the jury and the Court recognized that subjective qualities may be as or more important than those we can measure objectively, when suitability for certain uses is decided.

The authors of EPA’s Water Quality Criteria, upon which Virginia’s narrative standards are based, forcefully expressed the importance of those attributes the DEQ and the EPA have been asked to acknowledge and protect in this case. “Aesthetic qualities provide the general rules to protect water against environmental insults: they provide minimal freedom requirements from pollution; they are essential properties to protect the Nation’s waterways.” (U.S. EPA 1986, emphasis added).

After all, it is exactly these kinds of problems that motivated citizens to rise up and demand better protections and that led to adoption of the Clean Water Act. People complained not of parts per million of phosphorus or nitrogen but of water that smelled bad and was ugly; conditions where they were afraid or too repulsed by conditions to swim or boat.

In light of the high priority EPA apparently placed on these factors and the importance they hold for the general public, it is not credible to suppose that the Agency would have set a

criterion that was unusable - whose implementation would be “unscientific” and betray the dedication they’d shown to the scientific methods scientists had used in developing the many numeric criteria established in the same document.

Of course, water quality experts are not the only people who form common understandings about the subjective nature of resources and use common language as to the desirability of water bodies for recreational and aesthetic uses. The opinions of experienced fishermen, boaters, and guides and the ways they characterize conditions are part of a common understanding. The fact that dozens of river users quickly adopted the term “rock snot” to describe algal growths in the Shenandoah streams, shows that their perceptions could easily be summed-up in a term that could be understood by all.

As noted by Kain 2012, “blue-green algae mats” such as DEQ officials had seen floating in the North Fork Shenandoah River, “are quite often mistaken for sewage, due both to appearance and odor,” both of which Kain described as “definitely nasty” People readily use descriptions of known entities and sensations to describe things they cannot quantify or precisely label. At a minimum, it seems that a water body where conditions are described as “nasty” by DEQ officials or one where citizens “often mistake” the products of heavy algal growth for sewage must meet anyone’s definition of “undesirable” or as a “nuisance.”

A. Unnatural Colors

Do these waters exhibit unnatural colors?

The perception of color is central to the basic human sense of sight and the vast majority of humans can readily perceive when the waters near where they live and on which they recreate are relatively “normal” or not. This is a question that can be answered objectively and, while certain types of electronic instruments can provide quantitative measures of color, the human eye is the most appropriate instrument for measurement when the uses to be protected are human recreational and aesthetic uses.

Whether the color present in the water column obscures the bottom and makes wading and swimming dangerous or scary is a question that the eye of the potential user must answer. Likewise, whether the water’s color deters a potential user from fishing, because he or she cannot see a lure or the locations of habitat or fish underwater, is not a complex scientific question but one people who fish must answer. And people have answered these and other questions about how color affects their use of Shenandoah watershed streams. Forty of the commenters whose submittals are attached to this report specifically cited unusual colors in the streams as deterrents to their uses.

Kelble (Section X) notes that “when the planktonic/pelagic algae blooms in the river it turns a thick pea green color and fish become lethargic, they don’t find food effectively because they can’t see and they reduce their feeding” and “when a planktonic bloom colored the water and decreased visibility there was no chance to see fish and narrow your search, observe their habitat or even to sight fish specifically to an individual fish.”

Both scientists and members of the general public naturally compare the color of a stream they encounter to that in another part of the same stream or to a similar stream that is known to be in a relatively un-impacted state. The comparison of water body conditions with those in “reference” streams is a widespread and accepted method of assessing water quality. (See e.g.: U.S. EPA 2000; Dodds and Welch 2000) When conditions in a certain location are worse than those in one of these “reference” or “un-impacted” waters, then pollution problems may be assumed to be present - as long as the reference water body is truly close enough in type and underlying conditions to make the comparison valid.

It is true that, in some waters, organic materials or naturally-occurring minerals produce distinct colors. However, under natural conditions the water column of streams such as those in the Shenandoah valley streams have little or no color. The author of this report is aware of no stream in Virginia, or indeed in any part of the Southeastern or Mid-Atlantic regions of the U.S., where the kinds of colors shown in Figures 1 through 8 could possibly be considered to be “reference” conditions. In fact that these colors found in numerous locations in the Shenandoah watershed are not just marginally different from those in other streams in the region, they are startlingly different.

As stated in Section II, at least 40 of the comments received cited color in the water column as a problem that affected their use of the Shenandoah streams. That such colors exist, and over a wide range of areas, is easily determined by looking at Figures 1 - 8, which show conditions on the mainstem, at river miles 0, 22, and 39; on the North Fork at river miles 10 and 84; and on the South Fork at river miles 48 and 82.

Kelble’s expert testimony describes color problems in “one of the worst sections of the North Fork . . . between Broadway and Timberville [NF RMs 83-86]” where he states: “Repeatedly our observations in this section of river has shown extremely off-color water, green from a nearly continuous planktonic/pelagic algae bloom.”

That the descriptions of colored water given by commenters and those shown in the photographs submitted with this report match those from many other sources describing and warning of planktonic blue-green algae blooms, in the scientific literature, in news media, and in communications from government agencies (See Part F of this Section), can only lend added credibility and weight to complaints that were fully proven in 2012.

B. Unnatural Odors

Do these waters exhibit unnatural odors?

This is another question which can easily be answered with objective evidence and for which human senses are the best instrument of measurement. Note that, when detectable levels of odor are tested for in water and wastewater, a premier authority in such procedures cites “difficulties in testing for odor, including the fact that most odors are too complex and are

detectable at concentrations too low to permit their definition by isolating and determining the odor-producing chemicals.” (APHA 2012)

This same authoritative reference, Standard Methods for the Examination of Water and Wastewater, proposes Method 2150B, “the threshold odor test,” for determining odor thresholds in drinking water. Thus, in preferring human olfactory powers over laboratory methods, APHA (2012) verifies that people’s noses can meet the definition of “an accepted, scientifically valid assessment method that compares monitoring data to water quality standards or criteria.” (VA DEQ 2014b)

Sixty commenters specifically mentioned and described the odors they had encountered in using one or more of the Shenandoah streams. Many of the comments submitted with this report confirm the note in Kain (2012) that floating algal mats in the Shenandoah streams are often mistaken for sewage, due both to the odor and appearance of the mats. Some examples:

- * “the clumps had a sewage-like stench” (C7);
- * “numerous clumps of foul-smelling algae—this section of the river smelled like an outhouse” (C31);
- * “this algae smells like sewage or rotting broccoli” (C16);
- * “The algae had started to rot and the odor was horrible. It smelled like a combination of untreated human waste and a decaying body. The smell carried 1/3 of the way across the river; it took a long time for the smell to get out of my nostrils” (C60);
- * “this algae piles up into giant greenish brown mats. The smell is horrendous as if a dead animal carcass was encased in it.” (C26).

Some of those who have complained of such odors described specific ways in which their uses of the waters had been impaired or prevented:

- * “I have a Labrador retriever that absolutely loves the water. He’ll go in the river all year long to swim and drink. Many times, he’ll stink afterwards from getting algae in his fur. I always have to give him a bath after taking him to the river. Sometimes he’ll also throw up from drinking the river water.” (C40);
- * “the algae presents a foul odor (somewhere between sewage and a dead animal) such that you do not want to be on the river in a canoe or along the banks. . . . The older boys asked what was wrong with the river, when they smelled the algae and saw the slimy floating clumps during a brief canoe trip” (C69);
- * “During the summer one unfortunately has to check first for the presence of green algae clumps to determine if the river experience will be worth pursuing. These clumps smell terrible and are a strong indicator for my family and me to avoid recreating on or in the river. (C74)

Apparently DEQ and EPA did not consider such a compilation of reports from river users submitted in 2012 to constitute valid or sufficient data against which to compare that part of the narrative WQS, which states “Specific substances to be controlled include . . . substances that produce . . . odors.” As stated above, the presence or absence of odors is an objective matter. Dozens of citizens and a number of river recreation experts have complained of the odors and their complaints are supported by a DEQ official (Kain 2012). There are no evident reasons to

question the honesty of these many commenters nor are there reasons to think their senses of smell are defective. Therefore, violation of the WQS against odor in Virginia's water bodies is clearly proven.

C. Presence of Floating Materials

Are there unusual amounts or types of floating materials present in these waters?

This is another simple, objective question that is answered routinely by scientists performing stream studies or investigating pollution complaints. Both qualitative and quantitative measures can be used in this analysis and non-scientists who are avid and frequent river users are just as able to make conclusions, in many cases, as are technical experts.

The citizen testimony on this issue shows that commenters have observed unusual floating masses in the Shenandoah watershed streams on many occasions and in many locations. The expert opinions, both recreational and scientific, agree with the information provided by other river users. The photographs strongly support the citizen testimony.

Further discussion or exhaustive presentation and analysis of these sources is unnecessary. **The answer to the question “Are there unusual amounts or types of floating materials present in these waters?” is a strong and unequivocal “Yes.”**

D. Undesirable or Nuisance Plant Growths

Are there forms of undesirable or nuisance plant growths in these waters?

As stated above, and as noted by the Virginia DEQ (DEQ 2014b), findings of undesirable or nuisance conditions do depend on subjective judgments by humans. However, the DEQ's refusal to make judgments as to the presence or absence of such conditions cannot be based on a lack of reliable and defensible guidance and information in the scientific or regulatory literature.

The Department states in the current draft Integrated Report (DEQ 2014b), that “an ‘impaired’ designation can only be made based on specific and objective monitoring data.” This assertion is clearly wrong. Virginia law sets a criterion that is subjective. To assert that a measure of quality against which conditions are to be judged, whether legally or scientifically derived, may be set in subjective terms but that decisions as to whether water bodies meet that measure cannot validly be based on subjective evidence is nonsensical. Researchers are continually striving to develop standards of ecosystem health and water quality that are more easily measurable and reproducible. However, these efforts will always require subjective judgments.

The DEQ further states that “the terms ‘undesirable and nuisance’ . . . require interpretation” and implies that without “numeric thresholds” such interpretations may not be made in a way that is scientifically valid and defensible. “The fact that there is no widely

accepted, objective threshold by which “nuisance” conditions caused by excessive algae may be judged has certainly not deterred respected authorities in the field from using the term and declaring that “nuisance” algal growths exist under certain circumstances. An abundance of journal articles and contributions to scientific treatises demonstrate as much.

The following references are just a small sampling of published sources using the term and confidently defining or describing conditions that meet that threshold: Neil 1957; Horner et al. 1983; Lembi et al. 1988; Welch et al. 1988; Berlind 1992; Dodds and Welch 2000; Paerl et al. 2007; and Matheson et al. 2012; Stevenson et al. 2012. One representative definition, from Berlind (1992): “Algae levels can be considered a nuisance if the algae interferes with some aspect of recreational, commercial, or natural use of the river. This interference can be purely aesthetic or have some more tangible physical effect.”

Regulatory bodies in numerous jurisdictions also have not shown the kind of timidity that the Virginia DEQ has exhibited. The Saskatchewan Ministry of the Environment has stated that “certain aquatic plants and animals can be called ‘aquatic nuisances’ when they become present in sufficient numbers to pose problems for people or animals using a water body or its surrounding environment.” (Saskatchewan Min. of Envir. 2002)

By commissioning a study to assess the levels of algal coverage in stream beds that the public found unacceptable (Responsive Mgt. 2012), the West Virginia Department of Environmental Protection clearly signaled that the Department felt and accepted the responsibility of making regulatory decisions as to the levels of algal growth that were undesirable or rose to “nuisance” status.” Likewise, personnel from the Montana Department of Environmental Quality cited the body of scientific literature seeking to define “undesirable or nuisance level[s] of aquatic life in a water body” and decided that “some type of assessment of the public’s opinion on the matter is clearly warranted.” (Suplee et al. 2009)

New Zealand’s Ministry for the Environment released “guidelines for the control of undesirable biological growths in water (MfE 1992). These guidelines included nuisance plants (phytoplankton, benthic algae (periphyton) and macrophytes) and were provided for different waterbody types including lakes, rivers/streams and estuaries” in 1992 and again in 2000.

Having dispensed with the idea that subjective decisions as to whether Virginia’s narrative criterion prohibiting levels of pollutants in waterbodies “which nourish undesirable or nuisance aquatic plant life” cannot be validly made, the judgement as to whether such conditions exist in the Shenandoah River and other major streams in the watershed is relatively easy to make. Using the body of evidence presented in Sections II, III, IV, and V of this report the answer to the question “Are there forms of undesirable or nuisance plant growths in these waters?” is clearly and undeniably “Yes.” The analyses in parts A., B., C., E., and F. of this section (VI) support this conclusion in an overwhelming fashion.

To reinforce this conclusion even further, we refer to transect analyses described in Section V. of this report. As noted, this type of survey of stream bottom coverage by algae has been conducted by numerous parties.

After determining the percent coverage of various stream stretches, parties working on behalf of the West Virginia Department of Environmental Protection surveyed about one thousand individuals, for a population determined to provide a valid representation of all West Virginians 18 years old or older. (Responsive Mgt. 2012) While the West Virginia study broke responses down into categories, based on the types of activities for which respondents used rivers and other factors, the survey report found that, over the entire population of respondents, views with 26 percent bottom coverage were “unacceptable” to nearly half of respondents (49%) and concluded: “This suggests that waters with any more than a quarter coverage will be unacceptable to a majority of residents. (Ibid.) As one would expect, at higher percent cover levels those finding conditions unacceptable was also higher. Seventy-one percent (71%) of those surveyed found 39% coverage unacceptable; 87% found 47% unacceptable; and 90% found 65% bottom coverage by algae to be unacceptable.

The results of the West Virginia study are particularly suitable for comparison with conditions in the Shenandoah Valley, addressing streams and stream users from the same region of the country and with many similarities in environment, culture, and preferences. Therefore, the overall threshold derived by the West Virginia surveyors is appropriately compared to the transect sampling results obtained by SRK.

Given that the most precise level of bottom coverage averages that can be applied across all segments is likely at the individual transect level or at an even smaller scale due to variability in stream conditions, as discussed in Section V, the mean values for each of these transects have been examined to see how many are equal to or greater than a threshold value of 26% and of the higher percentage coverage levels. The results of this comparison show that at many points the stream bottom coverage greatly exceeds the 26% level.

Table 2 shows results by stream segment and date sampled and reveals that only one of the eight stream segments sampled for percent algal coverage, on the mainstem Shenandoah, failed to exceed West Virginia’s lowest threshold level. In fact, for every other segment, on the North and South Forks as well as North River and South River, the higher percentage threshold of 47% coverage (at which 87% found views unacceptable) was exceeded a least once. These results, combined with the data discussed above, indicates that undesirable or “nuisance” conditions are present throughout the Shenandoah watershed. The fact that heavy coverage was not found in the mainstem during June and July sampling does not indicate that high percent coverage does not occur here, though, because the photographic and witness evidence proves otherwise. This absence, as well as the absence of high cover in some other segments sampled, seems more likely to be related to the time of year and/or other factors. For example, that the South Fork segment between river miles 32 and 37 had drastically different results between samplings on June 14, 2012 and June 27, 2012.

Table 2 - Stream Bottom Algae Coverage

<u>Stream Segment</u>	<u>Date</u>	<u># of Transects Sampled</u>	<u># ≥ 26%</u>	<u># ≥ 39%</u>	<u># ≥ 47%</u>
North Fork Shen.					
(RMs 11 - 17)	6/15/12	22	10	2	1
	6/29/12	23	6	5	3
	7/16/12	21	10	7	6
(RMs 83 - 86)	6/26/12	10	6	4	2
	7/12/12	10	6	4	4
	7/26/12	5	0	0	0
South Fork Shen.					
(RMs 18 -21)	6/21/12	9	4	4	3
	7/10/12	10	3	2	1
(RMs 32 -37)	6/14/12	9	7	6	5
	6/27/12	12	1	1	0
	7/15/12	11	2	1	0
(RMs 75 - 80)	6/13/12	5	1	0	0
	6/28/12	11	0	0	0
	7/17/12	12	4	3	1
Main Stem Shen.					
(RMs 22 - 27)	6/20/12	17	0	0	0
	7/11/12	9	0	0	0
	7/25/12	2	0	0	0
North River					
(RMs 0 - 4)	6/23/12	18	4	4	1
	7/9/12	19	2	1	1
	7/23/12	7	0	0	0
South River					
(RMs 1 - 4)	6/16/12	14	5	4	3
	7/2/12	16	4	3	1
	7/14/12	13	1	0	0

E. Interference with Recreational Uses

Does the quality of these waters interfere with the recreational uses, including aesthetic enjoyment?

When river users say they have decided not to use a river or that conditions interfere with their traditional and habitual uses of the waters, then their testimony must be respected as a statement of fact, unless there is reason to believe their representations are untrue. More than 120 users, 8 of whom are river recreation experts, have testified that stream conditions related to excessive algal growth have interfered with their uses or eliminated them altogether.

All of the evidence discussed in section A. through D. above must also be considered in answering this question and must compel a positive response. “Noxious” and “nasty” odors, colors that make it impossible to see the river bottom to wade or fish, and benthic coverage by attached algae that greatly exceeds criteria, based on scientific surveys, to term waters unacceptable for use, floating masses of decaying algae - there is no rational basis to dispute that these are conditions that would deter most people from using and enjoying a river.

Further, these are exactly the kinds of algae-related problems that have been universally described in the scientific literature. While the author could quote from reference after reference from the list in Section IX of this report, such an exercise seems unnecessary.

However, one additional issue that has not been previously discussed is pertinent here and important to address. Heavy amounts of blue-green algae have been found throughout the Shenandoah River, both in phytoplankton and in attached algae. Just one source of evidence is found in Appendix H to this report. The images included there are satellite images in which spectral reflective signatures of several substances in the North Fork Shenandoah River are shown. These images indicate concentrations of chlorophyll and phycocyanin (the pigment in blue-green algae or cyanobacteria).

The results of the spectral imaging show that, not only were the blue-green algae/cyanobacteria present throughout the 70 miles of the North Fork we evaluated, it was present at high levels. In comparison to the chlorophyll analysis we did, the values for phycocyanin, which is the surrogate for blue-green algae/cyanobacteria were often higher than chlorophyll. Blue-Green algae/cyanobacteria negatively affect the ecosystem, present a potential danger to river users if they are developing toxins, and diminish peoples’ use and enjoyment, because they almost always lead to the kinds of results described in parts A. through D. above.

Beyond these physical and ecological impacts, blue-green algae are a deterrent to use of water bodies where they are found to “bloom,” because people rightly fear that toxins may be present. While not all forms of blue-green algae produce toxins and even where those that do produce them high levels are not necessarily found at any one time, the threat exists, and the uncertainties make it even harder for citizens and officials to react safely and appropriately to blue-green blooms.

SRK has obtained lab results for samples collected from the Shenandoah River and both Forks in April and May of 2014 (Appendix I), showing that at least two types of potentially toxicity-producing cyanobacteria are present in the Shenandoah watershed. The laboratory reports for these samples state, in part:

Microscopic observation of the . . . Farmers Mill sample collected on 4/18/2014 revealed the dominance of the filamentous cyanobacteria Phormidium cf. favosum. Phormidium autumnale and P. favosum share many morphological traits and are mainly separated based on habitat, slight differences in average trichome width and frequency of sheath formation. P. autumnale is described from mesotrophic to eutrophic streams and rivers, and P. favosum mostly from cold, flowing waters on limestone substrates. The trichomes observed in this sample fit the description for P. favosum. Phormidium autumnale and Phormidium favosum are both potential anatoxin producers. Recommendations: Toxin analysis for anatoxin is recommended at this time.

Based upon the laboratory's recommendation, samples were analyzed for toxins but found no detectable concentrations. Subsequently, testing has been done by personnel from the U.S. Geological Survey ("USGS") and detectable amounts of microcystin toxins have been found.

F. Interference with Aquatic Life Uses

Does the quality of these waters interfere with the maintenance of balanced, healthy aquatic communities?

The determination as to whether stream conditions in the Shenandoah River and its tributaries meet the requirement of supporting "the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them" is exactly the kind of scientific inquiry that stream ecologists make on a routine basis.

The Virginia DEQ has recognized that excessive algal growths may lead to certain impairments such as low dissolved oxygen and fish kills. However, the Department has failed to acknowledge a widely-recognized fact - that the presence of excessive and unusual growths of aquatic plants, including algae, represent an imbalance in the local ecosystem even if the known follow-on impacts are not present or measurable. The nature of algal populations in these streams can be compared to those in streams that are minimally affected or unaffected by high nutrient inputs and the extreme densities of certain types, such as those presented with this report, are not typical of "normal," or "un-impacted" streams in the region where the Shenandoah watershed lies.

"Blooms" of planktonic algae or very large populations of attached or floating algae are often the first step in producing the severe chemical and biological results. Whether the subsequent steps in degradation of water quality will result cannot necessarily be predicted based on the present of the blooms or excessive growths alone, because many other factors affect these outcomes. In fact, Voshell et al. 2000 stated, after they performed benthic macroinvertebrate

sampling throughout the watershed, that while conditions in the larger rivers were not yet affected in the same ways as numerous smaller streams by heavy nutrient loads that those larger streams would be so impacted if nutrient pollution continued.

That the scientific literature is replete with descriptions of the progressions that can occur, from heavy nutrient pollution, to excessive algal growth, to a plethora of outcomes is indisputable. One of the prominent changes that are intimately connected with the changing populations of algae, in both density and diversity, is the change in vascular plant health and populations, which can have cascading effects on benthic animals, on nutrient cycling, and on sediment washout patterns in-stream.

Example sources discussing this type of effect are:

Balls et al. (1989), explaining that in response to “very large” crops of phytoplankton “submerged plant growth may dwindle, with subsequent loss of the plant beds” and noting that “this represents a major change of structure in the ecosystem;”

Irvine et al. (1989) noting that great increases in nutrient inputs to freshwater systems frequently lead to “a switch from dominances by submerged plant communities to dominance by phytoplankton and that “the mechanism of this switch is generally seen in terms of a set of relationships between nutrient availability and competition between the plants and the algae” (internal citations omitted); and

Brönmark and Vermaat (1998) “Eutrophication of shallow freshwater . . . ecosystems has often resulted in a drastic decline in the areal extension and biomass of submerged macrophytes and a concomitant increase in the biomass of phytoplankton. Light availability is usually the most important factor determining the distribution pattern, biomass, and production of submerged macrophytes and it has been suggested that increasing phytoplankton biomass due to higher nutrient input results in a reduction of available light to a level at which net photosynthesis by submerged macrophytes is impossible).” Other researchers suggest “that macrophytes may disappear even when the bottom is within the euphotic zone” but “increasing nutrient levels stimulate epiphyton growth, which has a negative effect on the macrophyte host through shading and competition for nutrients.” (internal citations omitted)

Temporal Extent of WQS Violations

The problems with excessive algal growths and the consequences have persisted in the large streams within the Shenandoah River watershed on a yearly basis since 2007 or before. This window matches the stated coverage period for Virginia's 2014 Integrated Report.

Criteria which are designed to protect against negative impacts should have three dimensions:

- * level of severity of a condition to avoid problems (e.g. concentration of a pollutant),
- * length of occurrence allowed (how long can the condition exist for any one period?), and
- * frequency of occurrence (how many times can this recur over a period of time without uses being impaired?)

The narrative criteria/general standards set in Virginia's WQS do not specify time components (either length of one occurrence or recurrence of key conditions). Therefore, these features of the WQS must be interpreted such that the conditions named are prohibited - "nuisance" or "undesirable" conditions due to algae may not be created, unnatural odors and colors may not be caused, etc.

The lengths of time that any problem algae growths exist and the locations where they are found are extremely hard to predict, because changes in stream flow, temperature, sunlight, and any number of other factors can cause accumulations to form and be dispersed. The key is that, if these excessive growths occur even once, the baseline conditions (amounts of nitrogen, phosphorus, etc.) that were needed to produce that "bloom" are very unlikely to disappear without intervention. Therefore, if algal problems severe enough to produce the kinds of narrative violations described herein have occurred at any time and are proven, then a designation of impairment is appropriate. Further, the creation of a situation where people are unable to use their waters, even once, must be investigated and measures must be taken to prevent additional episodes.

In light of this analysis, the frequent and long-recurring excessive growths of various types of algae in many places in the Shenandoah watershed definitely meet the temporal requirements for an "impaired" designation.

Areal Extent of WQS Violation

The complex matrix of various algae-related problems identified on various sections of the Shenandoah River, as well as the North and South Forks, and other tributaries presents a picture of extremely heavy infestations of the mainstem, the North and South Forks, and North and South Rivers. While not all segments are plagued to the same degrees or at the same times by any one of the problems described and proven herein, more than one of the seven areas of violation of Virginia WQS is shown to reach nearly every river mile of the three larger streams. Because significant data is presented here for only the 4 miles nearest each of the mouths of

North River and South River, a judgment as to the degrees to which the remainders of these two Rivers are in violation of WQS would be premature.

To substantiate the extremely wide coverage of these streams by the variety of problems cited above (1-colors, 2-odors, 3-floating materials, 4-undesirable or nuisance growths, 5-interference with recreational uses, and 6-interference with aquatic life uses), series of maps have been prepared to represent the areal extent of just a limited sampling of the findings from the various assessment methods.

Although the evidence submitted in this report and attachments does show an extraordinarily widespread occurrence of algal problems on the stream segments where impairments have been found, it should be noted that standard proving the areal extent of problems required to designate larger stream segments applied to this survey effort is much more demanding than that applied in the DEQ's and the EPA's normal process for making "impaired" designations. Given that the excessive algal growths are biological indicators of stream health, in a way that can be compared to the representative nature of benthic macroinvertebrate surveys, similar rationales for setting the boundaries of "impaired" segments should be sufficient here. Benthic sampling is generally conducted on just one or a few sites within a relatively large stream reach and are held to represent conditions well beyond those sites. For example,

The Department's method for designating "Nutrient Enriched Waters," which the DEQ has followed in some circumstances, is just as strongly supported in these waters. Section 9VAC25-260-350. of the VA WQS regulations designated four waterbodies as "nutrient enriched" and in three of these four named waters, the downstream bounday of the segments is set while the upstream extent of the waters affected is listed as reaching "all tributaries to their headwaters." Such an approach is technically and practically justified in the regulation and is just as well supported for the waters draining to the Shenandoah River. At least some of the contributors of the conditions causing excess plant growths can be expected to reach to any upstream waters where the nature of the streams and the influences exerted on those streams are similar.

Findings as to the factors producing the excessive growths in Shenandoah watershed streams are beyond the capabilities of the studies so far completed. Therefore, measures to solve theses problems cannot possibly be designed at this time. Such determinations cannot be made with any degree of scientific validity and are not properly addressed at this stage of the regulatory process in any case. Despite this fact, Virginia officials have asserted that pollutant allocationns and controls mandated under the Chesapeake Bay TMDL may be adequate to address problems in these local waters. Such as assertion is unsound for a number of reasons.

First, and most obvious, is the fact that those Bay-related allocations were derived for the major tributaries to the Bay are made to address conditions in the estuarine waters of the Bay and those tributaries. The allocations that are applied to the various upstream waters in each of these major stream basins were then applied to upstream waters in a way that takes no account of the characteristics of upland and headwaters streams. In some instances, these basin allocations were then translated into required load reductions on a county-by-county basis in Virginia, based on the relative estimation of inputs from the various local areas and on the perceived

opportunities for reducing those pollutant amounts, based on known and estimated pollution sources. It is simply scientifically unsound to propose that such methods, which are based on large-scale modeling, could necessarily result in any significant improvement in specific headwaters streams, such as those we address in this report.

Second, it is universally acknowledged that the suite of factors needed to protect or restore waters subject to excessive growth will require examination of the particular characteristics of those streams. This is exactly the rationale used to avoid the setting of criteria for nutrients and sediments in the free-flowing waters of Virginia. The necessity of setting criteria with due consideration of regional conditions, including typical “background” conditions, hydrologic conditions, soils, stream flows, and other parameters has led EPA to recommend the development of criteria on ecoregion, or even sub-ecoregion bases, with the understanding that only such suitably tailored criteria are scientifically valid for local waters. (EPA ecoregion doc.)

Likewise, the Academic Panel tasked with recommending criteria for nutrients in Virginia’s upland waters has recommended measures for finding waters to be impaired or un-impaired, suggested different levels for each of four hydrogeologic provinces of the state upstream of the coastal plain. (Academic Panel report). Streams in the Shenandoah watershed arise in and flow through three of these provinces: with streams arising from the Blue Ridge on the east, the Appalachian Plateau on the west, and the central part of the watershed, which lies in the Valley and Ridge province. Given that such variability exists across the Shenandoah watershed, reliance upon allocations from the Bay TMDL, which fail to account for these differences in any detailed manner would be irresponsible and scientifically unsupportable. If Virginia officials thought otherwise, it would seem that the State would be confident in setting numeric criteria based upon the Bay allocations but, of course, this has not been the case.

Third, the Bay TMDL and Virginia’s implementation plans allow for permitting of discharges for facilities that exceed Bay-protective allocations to meet their goals through pollutant trading. In this way, facilities or activities may exceed allocations in one part of the Bay watershed where credits from load reductions in other parts of the watershed are to be achieved. (VA implementation plans) This aspect of the Bay cleanup plan invariably leaves some local streams without the protections supposed to result from the Bay TMDL. In fact, SRK has identified local streams where high pollutant loadings will continue unabated, because dischargers have bought credits from supposed load-reducers far away from the local environments we seek to protect.

VIII. Conclusions

- A. The level of information provided by citizens and SRK is, and was in 2012, more than sufficient and technically valid for making conclusions about the nature of impairments related to excessive algae growth in the Shenandoah watershed.
- B. The failure of the DEQ to develop methods to measure whether a water quality goal, such as the prohibition of discharges that result in nuisance conditions is inexplicable and does not conform to professional standards. These water quality standards, with the subject language, have been in force for approximately forty years - the author must ask what, if any, specific measures the DEQ has contemplated during that long period and why the State has failed to act before now.
- C. The DEQ's reluctance to value and make decisions based on evidence, such as citizen observations of issues well within the ability of the general public and the Department's failure to take any account of odor and color evidence, of which even the Department's personnel are well aware, is not a defense of valid scientific methods, as officials seem to suggest. Rather, it is a rejection of valid and appropriate assessment methods that are perfectly, and sometimes uniquely, suited to find the answers that are being sought.
- D. The evidence shows that the conditions that are prohibited in Virginia WQS which are analyzed for the Shenandoah watershed streams (listed in Section VI.A.- D.) , every one is exceeded, frequently and over large areas in the major streams. By any one of these measures, the Shenandoah River, the North Fork Shenandoah River, the South Fork Shenandoah River, and 4-mile segments of each the North and South Rivers are impaired and should be designated as such by Virginia and the U.S. EPA.

IX. Sources Cited or Relied Upon

- American Public Health Association, American Water Works Association, and Water Environment Federation, *Standard Methods for the Examination of Water and Wastewater*, 22nd Edition, January 5, 2012 (APHA 2012).
- Armitage, Anna R., Thomas A. Frankovich, Kenneth L. Heck, James W. Fourqurean, *Experimental nutrient enrichment causes complex changes in seagrass, microalgae, and macroalgae community structure in Florida Bay*, *Estuaries*, June 2005, Volume 28, Issue 3, pp 422-434 (Armitage et al. 2005).
- Balls, Hillary, Brian Moss, and Kenneth Irvine, *The loss of submerged plants with eutrophication I. Experimental design, water chemistry, aquatic plant and phytoplankton biomass in experiments carried out in ponds in the Norfolk Broadland*, *Freshwater Biology* (1989) 22, 71-87 (Included as attachment) (Balls et al. 1989).
- Barko J.W., M.S. Adams, and N.L. Clesceri, *Environmental factors and their consideration in the management of submersed aquatic vegetation—a review*, *J Aquat Plan Manag* 24:1–10, 1986 (Barko et al. 1986).
- Berlind, Perry, *Water Quality Benefits of the Missoula Phosphate Ban in the Clark Fork River*, Masters Thesis, UMI EP33903, 1992 (Berlind 1992).
- Biggs, Barry J. F. and Cathy Kilroy, *Stream Periphyton Monitoring Manual*, NIWA, Christchurch, Prepared for The New Zealand Ministry for the Environment, 2000 (Biggs and Kilroy 2000).
- Biggs, B.J.F., *New Zealand Periphyton Guideline: Detecting, Monitoring and Managing the Enrichment of Streams*. Ministry for Environment Publication, Wellington, 2000 (Biggs 2000a).
- Birk S, T. Korte, and D. Hering, *Intercalibration of assessment methods for macrophytes in lowland streams: direct comparison and analysis of common metrics*, *Hydrobiologia* 566:417–430, 2006 (Birk et al. 2006).
- Bjorkland, Ronald Catherine M. Pringle, and Bruce Newton, *A Stream Visual Assessment Protocol (SVAP) for Riparian Landowners*, *Environmental Monitoring and Assessment* 68: 99–125, 2001 (Bjorkland et al. 2001).
- Blankenship, Karl, *Scientists investigate cause of sores on striped bass*, *Bay Journal*, November 1, 1997, http://www.bayjournal.com/article/scientists_investigate_cause_of_sores_on_striped_bass (Blankenship 1997).
- Brönmark, Christer and Jan E. Vermaat, *Complex Fish-Snail-Epiphyton Interactions and Their Effects on Submerged Freshwater Macrophytes*, *The Structuring Role of Submerged Macrophytes in Lakes Ecological Studies Volume 131*, 1998, pp 47-68 (Brönmark and Vermaat 1998).
- Camacho, F.A. and R. W. Thacker, *Amphipod herbivory on the freshwater cyanobacterium *Lyngbya wollei*: chemical stimulants and morphological defenses*, *Limnology and Oceanography* 51:1870–1875, 2006 (Camacho and Thacker 2006).
- Camacho, F.A., *Macroalgal and cyanobacterial chemical defenses in freshwater communities*, pp. 105–119 in *Algal chemical ecology*, ed. C. D. Amsler, Springer, Heidelberg, Germany, 2008 (Camacho 2008).
- Carlisle, Darren M., Michael R. Meador, Terry M. Short, Cathy M. Tate, Martin E. Gurtz, Wade L. Bryant, James A. Falcone, and Michael D. Woodside, *The Quality of Our Nation's Waters, Ecological Health in the Nation's Streams--1993—2005*, U.S. Geological Survey Circular 1391, 120 p., <http://pubs.usgs.gov/circ/1391/>, (Carlisle et al. 2013).
- Cermak, Michael, Eric Crandall, and Julie Young, *Wastewater Nitrogen is Linked to Changes in Submerged Aquatic Vegetation and Invertebrates in Oyster Pond*, Boston University Marine Program, Marine Biological Laboratory, Woods Hole, MA 02543, undated (Cermak et al.).

- Dodds, Walter K., *Eutrophication and trophic state in rivers and streams*, Limnol. Oceanogr., 51(1, part 2), 2006, 671–680 (Dodds 2006).
- Dodds, Walter K. and Eugene B. Welch, *Establishing nutrient criteria in streams*, J. N. Am. Benthol. Soc., 2000, 19(1):186–196 (Dodds and Welch 2000).
- Duarte, C.M., *Submerged aquatic vegetation in relation to different nutrient regimes*, Ophelia 41:87–112, 1995 (Duarte 1995).
- Environment Canada, *State of the Great Lakes 2009 Highlights*, <http://www.ec.gc.ca/grandslacs-greatlakes/default.asp?lang=En&xml=0DDDB4BF-7A69-41AE-B88A-90706C41707B>, viewed 12/20/14 (Environment Canada 2014).
- Gerard C., A. Carpentier, and J. M. Paillisson, *Longterm dynamics and community structure of freshwater gastropods exposed to parasitism and other environmental stressors*, Freshwater Biology 53:470–484, 2008 (Gerard et al. 2008).
- Griggs, A., J. Cummins, and C. Buchanan, *Filamentous Algae Monitoring Pilot Program: West Virginia Rivers of the Potomac River Basin*, Report prepared by Interstate Commission on the Potomac River Basin for the West Virginia Department of Environmental Protection, Water Quality Standards Program, ICPRB Report 12-07 (Griggs et al. 2012).
- Haris, Hazzema, *Water Quality and Periphytic Algae Community of Petani River Basin, Kedah*, Masters Thesis, June 2009 (Haris 2009).
- Hart, D.D., *Grazing insects mediate algal interactions in a stream benthic community*, Oikos 44:40–46, 1985 (Hart 1985).
- Hauxwell, J., J. Cebrian, C. Furlong, and I. Valiela, *Macroalgal canopies contribute to eelgrass (*Zostera marina*) decline in temperate estuarine ecosystems*, Ecology 82:1007–1022, 2001 Hauxwell et al. 2001).
- Heisler, J., P.M. Glibert, J.M. Burkholder, D.M. Anderson, W. Cochlan, W.C. Dennison, Q. Dortch C.J. Gobler, C.A. Heil, E. Humphries, A. Lewitus, R. Magnien, H. Marshall, K. Sellner, D.A. Stockwell, D.K. Stoecker, and M. Suddleson, *Eutrophication and harmful algal blooms: A scientific consensus* (2008). U.S. Environmental Protection Agency Papers. Paper 169 (Heisler et al. 2008).
- Hem, John D., *Study and Interpretation of the Chemical Characteristics of Natural Water, Third Edition*, U.S. Geological Survey Water-Supply Paper 2254, 1985 (Hem 1985).
- Horner, R.R., E.B. Welch, and R.B. Veenstra, *Development of nuisance periphytic algae in laboratory streams in relation to enrichment and velocity*, in: *Periphyton of Freshwater Ecosystems*, ed. R.G. Wetzel, pp. 121–134. Dr W. Junk Publishers, The Hague, 1983 (Horner et al. 1983).
- Hughes, A. Randall, K. Jun Bando, Laura F. Rodriguez, and Susan L. Williams, *Relative effects of grazers and nutrients on seagrasses: a meta-analysis approach*, Mar Ecol Prog Ser 282: 87–99, 2004 (Hughes et al. 2004).
- Hynes, H.B.N., *The Biology of Polluted Waters*, Liverpool University Press, 1966.
- Irvine, Kenneth, Brian Moss, and Hillary Balls, *The loss of submerged plants with eutrophication II. Relationships between fish and zooplankton in a set of experimental ponds, and conclusions*, *Freshwater Biology* (1989) 22, 89–107 (Included as attachment) (Irvine et al. 1989).
- Jones, J. Iwan, Johnstone O. Young, John W. Eaton, and Brian Moss, *The influence of nutrient loading, dissolved inorganic carbon and higher trophic levels on the interaction between submerged plants and periphyton*, *Journal of Ecology*, Volume 90, Issue 1, pages 12–24, February 2002 (Included in attachments) (Jones et al. 2002).
- Kain, Donald, Virginia DEQ, email to Leslie Mitchell RE: *Cow poop dumping*, July 9, 2012 (Included in attachments as C120) (Kain 2012).

- Karr, J.R., and D.R. Dudley, *Ecological perspective on water quality goals*, Environmental Management 5: 55-68, 1981 (Karr and Dudley 1981).
- Kornijo' W. R., K. Vakkilanen, J. Horppila, E. Luokkanen, and T. Kairesalo, *Impacts of a submerged plant (Elodea canadensis) on interactions between roach (Rutilus rutilus) and its invertebrate prey communities in a lake littoral zone*, Freshwater Biology 50:262–276, 2005 (Kornijo' et al. 2005).
- Lake Erie Phosphorus Objectives Review Panel, *Preliminary Comments*, December 10, 2014.
- Larson, Chad A. and Sophia I. Passy, *Taxonomic and functional composition of the algal benthos exhibits similar successional trends in response to nutrient supply and current velocity*, FEMS Microbiol Ecol 80 (2012) 352–362 (Larson and Passy 2012).
- Lembi, Carole A., Steven W. O'Neal, and David F. Spencer, *Algae as weeds: economic impact, ecology, and management alternatives*, in: Algae and Human Affairs, eds. Carole A. Lembi and J. Robert Waaland, Cambridge Univ. Press, 1988 (Lembi et al. 1988).
- Liston, S. E. and J. C. Trexler, *Spatiotemporal patterns in community structure of macroinvertebrates inhabiting calcareous periphyton mats*, Journal of the North American Benthological Society 24:832–844, 2005 (Liston and Trexler 2005).
- Madsen, John D. and Michael S. Adams, *The distribution of submerged aquatic macrophyte biomass in a eutrophic stream, Badfish Creek: the effect of environment*, Hydrobiologia 171: 111-119, 1989 (Madsen and Adams 1989).
- Maryland Department of Natural Resources, *Chesapeake Bay Life: What You Should Know About Pfiesteria*, <http://www.dnr.state.md.us/bay/cblife/algae/dino/pfiesteria/facts.html#abnormal>, (MD DNR 2014).
- Matheson F., J. Quinn, and C. Hickey, Review of the New Zealand instream plant and nutrient guidelines and development of an extended decision making framework: Phases 1 and 2 final report, NIWA Client Report No: HAM2012-081, for the Ministry of Science & Innovation Envirolink Fund, August 2012 (Matheson et al. 2012).
- McGlathery, K. J., *Nutrient and grazing influences on a subtropical seagrass community*, Marine Ecology Progress Series 122:239-252, 1995 (McGlathery 1995).
- McKee and Wolf, *Water Quality Criteria, Second Edition*, California State Water Resources Control Board, Publication 3-A, 1963 (Reprint June 1, 1974) (McKee and Wolf 1963).
- Murdock, Justin N. and Walter K. Dodds, *Large Rivers and Eutrophication*, Division of Biology Kansas State University, http://n-steps.tetrattech-ffx.com/PDF&otherFiles/literature_review/Eutrophication%20effects%20on%20large%20rivers.pdf (viewed 12/1/14) (Murdock and Dodds 2014).
- Neil, John H., *Investigations and Problems in Ontario*, In: Biological Problems in Water Pollution - Transactions of a Seminar on Biological Problems in Water Pollution held at the Robert A. Taft Sanitary Engineering Center Cincinnati, Ohio April 23 - 27, 1956, ed. Clarence M. Tarzwell, 1957, (Neil 1957).
- Norkko, J., E. Bondsdorff, and A. Norkko, *Drifting algal mats as an alternative habitat for benthic invertebrates: species specific responses to a transient resource*, Journal of Experimental Marine Biology and Ecology 248:79–104, 2000 (Norkko et al. 2000).
- Paerl, Hans W., Lexia M. Valdes-Weaver, Alan R. Joyner, and Valerie Winkelmann, *Phytoplankton Indicators of Ecological Change in the Eutrophying Pamlico Sound System, North Carolina*, Ecological Applications, 17(5) Supplement, 2007, pp. S88–S101 (Paerl et al. 2007).
- Paerl, Hans W., Karen L. Rossignol, S. Nathan Hall, Benjamin L. Peierls, and Michael S. Wetz, *Phytoplankton Community Indicators of Short- and Longterm Ecological Change in the Anthropogenically and*

- Climatically Impacted Neuse River Estuary, North Carolina, USA*, Estuaries and Coasts (2010) 33:485–497 (Paerl et al. 2010).
- Penning, W. Ellis, Marit Mjelde, Bernard Dudley, Seppo Hellsten, Jenica Hanganu, Agnieszka Kolada, Marcel van den Berg, Sandra Poikane, Geoff Phillips, Nigel Willby, Frauke Ecke, *Classifying aquatic macrophytes as indicators of eutrophication in European lakes*, Aquat Ecol (2008) 42:237–251, (Penning et al. 2008).
- Poff, N. LeRoy, J. David Allan, Mark B. Bain, James R. Karr, Karen L. Prestegard, Brian D. Richter, Richard E. Sparks, Julie C. Stromberg, *The Natural Flow Regime*, BioScience, Vol. 47, No. 11 (Dec., 1997), pp. 769-784 (Poff 1997).
- Poirier, Anne-Marie Tourville, Antonella Cattaneo, and Christiane Hudon, *Benthic cyanobacteria and filamentous chlorophytes affect macroinvertebrate assemblages in a large fluvial lake*, J. N. Am. Benthol. Soc., 2010, 29(2):737–749 (Poirier 2010).
- Responsive Management, *West Virginia Residents' Opinions on and Tolerance Levels of Algae in West Virginia Waters*, Conducted for the West Virginia Department of Environmental Protection, 2012 (Responsive Mgt. 2012).
- Rosenberg, D. M. and V. H. Resh, *Freshwater biomonitoring and benthic macroinvertebrates*, Chapman and Hall, New York, 1993 (Rosenberg and Resh 1993).
- Sacramento River Watershed Program, *Sacramento River Basin Report Card, 3.1.1 Periphyton Cover and Biomass*, http://www.sacriver.org/aboutwatershed/reportcard/section3/section3_1/311-periphyton-cover-and-biomass, viewed December 2014 (SRWP 2014).
- Salovius, S. and P. Kraufvelin, *The filamentous green algae Cladophora glomerata as a habitat for littoral macrofauna in the Northern Baltic Sea*, Ophelia 58: 65–78, 2004 (Salovius and Kraufvelin 2004).
- Sand-Jensen, K., *Effect of epiphytes on eelgrass photosynthesis*, Aquat Bot 3:55–63, 1977 (Sand-Jensen 1977).
- Sand-Jensen, K., N.P. Revsbech, B.B. Jorgensen, *Microprofiles of oxygen in epiphyte communities on submerged macrophytes*, Mar Biol 89:55–62, 1985 (Sand-Jensen et al. 1985).
- Saskatchewan Ministry of Environment, Water Security Agency, *A Guide to Aquatic Nuisances and Their Control*, November 2002, EPB #47 (Saskatchewan Min. of Envir. 2002).
- Stevenson, R. Jan, Brian J. Bennett, Donielle N. Jordan, and Ron D. French, *Phosphorus regulates stream injury by filamentous green algae, DO, and pH with thresholds in responses*, Hydrobiologia October 2012, Volume 695, Issue 1, pp 25-42 (Stevenson et al. 2012).
- Suren A.M., *Effects of deposited sediment on patch selection by two grazing stream invertebrates*, Hydrobiologia 549:205–218, 2005 (Suren 2005).
- Suren, A.M. and T. Riis, *The effects of plant growth on stream invertebrate communities during low flow: a conceptual model*, Journal of the North American Benthological Society 29(2):711-724, 2010 (Suren and Riis 2010).
- Tomasko, D. A. and B. E. Lapointe, *Productivity and biomass of Thalassia testudinum as related to water column nutrient availability and epiphyte levels: field observations and experimental studies*, Marine Ecology Progress Series 75:9-17, 1991 (Tomasko and Lapointe 1991).
- Tracy, M., J.M. Montante, T.E. Allenson, and R.A. Hough, *Long-term responses of aquatic macrophyte diversity and community structure to variation in nitrogen loading*, Aquatic Botany 77 (2003) 43–52 (Tracy et al. 2003).
- U.S. Environmental Protection Agency, *Quality Criteria for Water, 1986*, EPA 440/5-86-001 (U.S. EPA 1986).

- U.S. Environmental Protection Agency, *Ambient Water Quality Criteria Recommendations, Information Supporting the Development of State and Tribal Nutrient Criteria Rivers and Streams in Nutrient Ecoregion IX*, EPA 822-B-00-019, December 2000 (U.S. EPA 2000).
- U.S. Environmental Protection Agency, *National Rivers and Streams Assessment, 2008 - 2009, A Collaborative Survey - Draft*, EPA/841/D-13/001, February 28, 2013 (U.S. EPA 2013a).
- Valiela, I., J. McClelland, J. Hauxwell, P.J. Behr, D. Hersh, and K. Foreman, *Macroalgal blooms in shallow estuaries: controls and ecophysiological and ecosystem consequences*, *Limnology and Oceanography* 42:1105-1118, 1997 (Valiela et al. 1997).
- Virginia Department of Environmental Quality, *Fish Kill Guidance Manual, Second Edition*, March 2002 (VA DEQ 2002).
- Virginia Department of Environmental Quality, *Virginia Harmful Algal Bloom Task Force*, <http://www.deq.state.va.us/Programs/Water/WaterQualityInformationTMDLs/WaterQualityMonitoring/VirginiaHarmfulAlgalBloomTaskForce.aspx>, website viewed December 2014 (VA DEQ 2014a).
- Virginia Department of Environmental Quality, *Virginia Water Quality Assessment 305(b)/303(d) Integrated Report 2014 - Draft*, Richmond, Virginia, December 2014 (VA DEQ 2014b).
- Virginia Department of Game and Inland Fisheries, *Shenandoah River - North Fork*, <http://www.dgif.virginia.gov/fishing/waterbodies/display.asp?id=172>, Last Viewed 12/17/14 (screenshot contained in Appendix __) (VDGIF, 2014).
- Virginia Institute of Marine Science, *The Impact of Mycobacteriosis on Recreational Striped Bass Fishing Year II: What is the Fate of Infected Fish?*, Proposal Submission to Saltwater Recreational Fishing Advisory Fund, June 2005 (VIMS 2005).
- Voshell, J. Reese, Jr., Chris L. Burcher, Amy Braccia, Donald J. Orth, *Using Benthic Macroinvertebrates to Identify Causes of Fish Kills in the Shenandoah River (2006 and 2007)*, In fulfillment of Virginia Tech Project # 208-11-110438 T-007-841-1, FRS # 447693; Sponsored by Virginia Department of Game and Inland Fisheries, Sponsor # 2006-9553, October 15, 2008 (Voshell et al. 2008).
- Walker D.I., A.J. McComb, *Seagrass degradation in Australian coastal waters*, *Mar Pollut Bull* 25:191–195, 1992 (Walker and McComb 1992).
- Welch, E. B., J. M. Jacoby, R. R. Horner, AND M. R. Seeley, *Nuisance biomass levels of periphytic algae in streams*, *Hydrobiologia* 157: 161–168, 1988 (Welch et al. 1988).
- Western, David, *Human-modified ecosystems and future evolution*, *Proceedings of the National Academy of Sciences*, PNAS 2001 98 (10) 5458-5465; doi:10.1073/pnas.101093598 (Western 2001).
- Yam, Rita S.W., Matthew O'Hare, Michael J. Dunbar, Annette Baattrup, and Søren E. Larsen, *River management: use of macrophyte community structure in UK rivers as an example for ecological assessment for hydromorphological impacts*, *Proceedings of the 4th IASME / WSEAS Int. Conference on Water Resources, Hydraulics & Hydrology (WHH'09)*, 2009 (Yam et al. 2009).
- Zheng, Lei, PhD and Michael J. Paul, PhD, *Effects of Eutrophication on Stream Ecosystems*, Tetra Tech, Inc. (Zheng and Paul).
- Zingone, Adriana and Henrik Oksfeldt Enevoldsen, *The diversity of harmful algal blooms: a challenge for science and management*, *Ocean and Coastal Management*, 43 (2000) 725-748 (Zingone and Enevoldsen 2000).

X. Expert Testimony from Jeff Kelble

Statement of Jeff Kelble
January 28, 2015

I am submitting this document for inclusion in the comments presented to the Virginia Department of Environmental Quality (DEQ) regarding the 2014 Draft Integrated Report, on behalf of Potomac Riverkeeper and Shenandoah Riverkeeper. I will include my observations about some particular problems I've observed in the watershed, because I believe some of them may not have been as well explained as some other problems by algae. I also believe that there I am better equipped to address these issues than anyone else I know of. After those descriptions and opinions, I describe my background and the way I came to be an expert on fishing, fish behaviours, and the environment of the streams in the Shenandoah, as well as many other streams. Because I made my living by knowing about these things, I depended on all of the training and information I'd received, both from others and through my determination to teach myself.

During my career as a heavy user of the Shenandoah and other mid-atlantic rivers, with a pattern of use heavier than any other known individual, and as a professional fishing guide for nine years, I became extremely familiar with the seasonal rhythms of our rivers. The quality of the fishing trips I was able to provide hinged on the river that I chose. One of the primary factors for choosing both the river I fished and the stretch of that river was the physical condition of the river. Smallmouth bass are residents of our Mid-Atlantic rivers. They are always there. They are also generalist predators so for much of the year they occupy most or the river from bank to bank, along nearly every mile. They also feed almost every day between March and November. So the biggest driving force to catching fish was the ability of the fish to see your lure/bait, and the ability for you to make an unimpeded presentation.

First though I want to make an overall statement. The environment for fish and for people in most parts of the Shenandoah Mainstem and the North and South Forks has deteriorated greatly since I started fishing here and the effects of an explosion of algae are very serious and destructive. As DEQ and EPA officials, I have been petitioning to have these rivers listed as impaired for some years now and I am frustrated that the agencies have not used the information I and others have given them. I renew my request that the listing be made now.

Comparisons with Other Streams

As a professional fishing guide I used four stretches of the Potomac River, three stretches of the North Fork, three stretches of the South Fork, three stretches of the main stem, three stretches of the Rappahannock, one stretch of the Rapidan, two stretches of the James River, three stretches of the Susquehanna River and five stretches of the New River. It is widely accepted that my guiding business was unique in that I made a living as a smallmouth bass guide through all four seasons. There was no other person who spent as much time on these various bodies of water.

I can say, without question that there is no other river, stream, or lake I have observed which even approaches the Shenandoah River in the temporal and spatial coverage of algae, nor has any

river ever achieved the severity of bloom that the Shenandoah Rivers experience. I have even fished in rivers with heavy populations of people like the Rappahannock River and Potomac River downstream of towns and cities like Fredericksburg, Culpeper, Warrenton. The Rappahannock and Rapidan, while heavily affected by sediment pollution has never exhibited heavy algae growth of any kind.

The Potomac River, with the exception of the waters downstream of where the Shenandoah pours into it, has occasional algae blooms. Except in the areas downstream of the Shenandoah influence these algae blooms are light and sporadic. The grasses in these areas still predominate and are healthy and lush. I have never observed the algae interfering with fishing. However in the areas downstream of the Shenandoah the algae can be extremely prolific and does affect fishing. I have observed and other guides have corroborated that when the Shenandoah has algae blooming in it the fish in the Shenandoah-influenced water are lethargic or absent. The affects of this can be observed down to Swains Lock Virginia downstream of Violets Lock. In these areas the same colonized algae form in the summer after one or two months of planktonic/pelagic bloom.

The New River downstream of Radford and the Arsenal have occasional light blooms of colonized algae but I would estimate that the river sees 1-2% of what the Shenandoah River sections see.

The Susquehanna Downstream of Harrisburg and the farming areas of Lancaster has the most algae I've seen on any other Mid-Atlantic River, but doesn't approach the degree or depth of algae that the Shenandoah produces.

Concerns with the Upstream Reaches of the North Fork

Access is very limited on the Upper North Fork but we spent a significant amount of time observing sections we had access to. One day, day for example, I followed the algae bloom upstream into Broch's Gap, up the North Fork, up Fulks Run and up to Hopkins Gap. Algae was heavy all the way upstream until I found a place where the stream flowed out form between the cobblestones just downstream from a poultry operation. There was heavy algae that high up the river and filled the water column.

One of the worst sections of the North Fork is that between Broadway and Timberville. Repeatedly our observations in this section of river has shown extremely off-color water, green from a nearly continuous planktonic/pelagic algae bloom. During low flows in the summer this stretch is literally choked with algae. It's so heavy that the turtle carapaces are often completely covered with algae. River users under the Route 42 Bridge have complained to us during our investigations and have thought the blue green clumps on the surface were actually raw sewage from the Cargill/Pilgrims/ Broadway discharge.

Algae's Impacts on Underwater Grasses in the Shenandoah Watershed

I have taken specific interest in these kinds of impacts, because the process has been quite visible and disturbing. I know that a number of commenters mentioned such concerns and that quite a few of the photos in our collection show dead and dying grasses covered by thick algae coatings.

For example, for the section of river between Route 50 and Lockes Landing on the Main Stem Shenandoah, grasses predominated during the period between 1994 when I started using this float and 2002 which is the last season any substantial grasses were observed. During 2002, the river was so lush with grass which grew in nearly the entire 16 mile length from bank to bank. That year the majority of flow of the river existed under the shade of the tree canopy along the bank.

During those years small fish and bugs found tremendous refuge in the grasses. The spaces in between the grasses were full of the predatory fish. Very little algae was ever present during the lush periods of grass growth. I did notice during the very last year of 2002, that during the lowest flows many of the grasses began to be covered by algae growth during the end of the summer and very low flow. But the preponderance of growth was grass. However, that year marked the last time grass was observed in any quantity and now what we have from year to year are small vestige patches at times miles apart. These grasses emerge in late May only to be overwhelmed by algae which grow on top of the grasses causing the leaves to fall off. What remains are grass stems.

I have made the exact same observations regarding the North Fork between Deer Rapids and Strasburg except the algae took over earlier. During the peak of the drought in 1999 I recall the VDGIF predicting that there would be a full wipeout of the fish population in the North Fork if the algae in the river died before a substantial flushing event. I fished the North fork a number of times during that period and could not believe the extent of algae growth. There were places where the algae was three feet thick and it filled up the water column in the slowest areas. Blue Green Algae's predominated but there were also filamentous greens that both covered the bottom AND filled the water column in the slowest flowing backwaters. Fish went nearly dormant in their feeding. On approximately September 7th a tropical storm flushed the river with a 7 foot rise. I fished three days later and the river was clear of algae but there were huge piles of it on the bridge pilings and on everything stationary along the banks including rocks, trees and tree limbs. The fish were literally ravenous and had begun feeding again. I was with professional guide Lou Giusto who specialized in the North Fork Smallmouth and we noted that every cast for several hours we hooked a fish and there would be up to a dozen starving fish following the hooked fish to the boat hoping to pick up regurgitated scraps.

Since then this section of the North Fork has been one that I spent a lot of time on fishing, guiding and observing. Each year the grasses and the algae engage in a battle for space and dominance. Most years now the algae wins and the grasses are stunted, die or never emerge.

The same exact pattern has emerged on the South Fork, the area I have frequent most as a professional has been the section of river from Andy Guest State Park downriver to Karo Landing.

Personal History

My history with fishing began at the age of 5 during a trip to the finger lakes. Like many kids I experienced an immediate attraction to fishing but it seemed like my interest went way beyond normal and when I look back at the patterns, I tended to orchestrate most of the rest of my life

around fishing in some way. When I was in second grade I moved to a house in rural Massachusetts surrounded by a network of streams connected to natural and man-made ponds.

By fourth grade I was fishing three to four days a week May through October. I learned how to catch minnows, worms, frogs, salamanders, crayfish, and just about every other possible live bait by the time I was nine, and used all of them. I sold golden shiners to my friends when I was ten after I taught myself how to catch more than I needed for my own fishing. I used my skateboard to transport myself and my bait from pond to pond, stream to stream, identifying and fishing the water body that was in the best condition and was fishing best. I learned this from a young age.

In fourth grade I proposed a school project which constituted taking time during the school week to travel all over the state to find access to, paddle and fish most of the rivers, ponds and lakes in half of the State of Massachusetts. My project included authoring a book called “Fishing In Massachusetts.” My best friend and I pooled our lawn-mowing money and bought a canoe which we learned to transport, with our parents permission and help, on top of their cars. My mother and my teacher took their time to work with my friend and I for over a year researching for the book which was published by fifth grade and carried by most of the region’s fishing and tackle stores.

Additionally, our family acquired a saltwater boat when I was approximately 8 years old and our weekends through the summer were spent traveling down the Charles River, through the Locks into the Boston Harbor. We spent hundreds of days through high school exploring the islands, feeder streams to the bays and harbors of the New England coast, sleeping on our boat, fishing, and swimming where we went.

By the time I graduated high school I estimate I had fished over 1000 days on more than 200 bodies of water around inland Massachusetts as well as the coasts from Salem to Block Island. I had fished rivers from the Penobscot in Maine to tributaries of the Connecticut River in Western Massachusetts, all the way down to rivers and streams in Connecticut and Rhode Island. There wasn’t a stream that was safe or private property we weren’t willing to cross to get to our fishing destinations. I cringe at the thought, but am thankful for understanding landowners. We left no trace. I also fished and explored rivers and streams in Montana, Colorado and Wyoming, all the way up to and through Calgary Canada.

In college I set up carp fishing tournaments on the incredibly impaired Mystic River. I was determined to fish. In our tournaments our goal was not to catch the biggest or the most fish, it was to see how many different things we could use to catch carp. Our fishing was limited to the region around college but we explored the mostly polluted rivers and water storage reservoirs north of Boston.

After graduating college my roommate and I moved to Virginia from Massachusetts and our stated reason for the move to our parents was that the fishing season was longer. We ogled at the idea that we might be able to fish through the winter some years. Living in Arlington I built relationships with the local fishing and flyfishing communities, fishing stores and rod/reel repair shops and began exploring and fishing the waters of the Mid-Atlantic with . Over twenty years

this exploration continues and I have walked, fished and seen hundreds of bodies of water as a result. Here are some details:

In 1995 I joined the 200+ member Potomac River Smallmouth Club. By 2001 I had won every fishing contest in the club for several years running, had served as Newsletter Editor, Vice President and President.

Along the way I was invited to guide for Mark Kovach Fishing Services in Harper's Ferry, learned how to row an oar rig, and guided my first year in 1999 approximately 60 days. By the end of 2000 I had built a full time business and guided March through November, 5 days a week through 2005, a total of seven years. I spent three years guiding part time even after starting the Shenandoah Riverkeeper program during 2006 as I continued guiding six weeks a year for several more years.

Another example of the breadth of my experience on Virginia waters was my participating in the development of the "Flyfishers Guide to Virginia". author David Hart got a contract to write the "Flyfishers Guide to Virginia" and he asked me to be his primary companion in exploring most of the fishable streams, rivers, and reservoir in the state ranging from Goose Creek in Loudon County to the South Holston Reservoir on Virginia's Southern border and the mountain and valley streams in between. We fished for trout, bass and everything with fins and a mouth, at times camping along the way and at other times sustenance fishing.

In 2000 I helped LL Bean open their first retail store outside of Maine by setting up a flyfishing shop in Tysons Corner, and I also worked with their staff to start up their first flyfishing school outside of Maine. I taught their 1, 2 and 3 day classes for the next five years until my guide schedule became so heavy I had no time left to teach. During my time as an instructor I took hundreds of students to the water and into their first fishing experiences in multiple locations in the Shenandoah Valley centered near Front Royal.

By 2003 I had moved to the Shenandoah Valley to tend to my full guiding schedule which meant over 150 guided days per year. In addition to those 150 days I spent another 50 days with other professional guides exploring new water, learning existing water and working on new fishing techniques. My wife and I completed renovation of our old home in 2005 and opened a bed and breakfast to cater to our fishermen. We integrated the bed and breakfast with my guide business.

When we lost 80% of the smallmouth and sunfish population in the Shenandoah during 2005 and 2006 I was invited to join Virginia's Fish Kill Task Force as a fishing guide. This task force convened for five years and engaged in an extremely robust series of studies to determine why fish were sick in the Shenandoah and why we lost huge numbers of fish during 2005 and 2006. Looking back, while no single cause has been identified, most of the theories that had evidence to support them related to water quality. We considered the role of ammonia from high nutrient loads and decomposition of nutrients, we considered toxic algae, we considered the role of pesticides and herbicides, we looked at a range of other factors.

During this time I provided countless hours of witness and testimony to the poor health of the Shenandoah River fish even during the years before the fish kills. Every published scientific study

from the Fish Kill Task Force shows a correlation with many factors that have a link to algae growth. 1) Herbicides have been found in high concentrations which studies show would hold back the growth of native grasses and favor algae growth 2) High nutrient loads lead to heavy algae growth which causes daily spikes in water PH, which leads to increased toxicity from existing ammonia 3) High parasite load mainly due to the extreme proliferation of the Leptoxis Snail which hosts parasites that prey on the same species of fish which are sick. The snails themselves feed on algae and proliferate due to the extreme algae levels. One study showed that the Leptoxis snail constituted the majority of the entire biomass alive in the river. This is tremendously informative when looking at the algae issue.

I testified that starting in May of every year, smallmouth bass lose a tremendous amount of weight, and muscle fitness. Smallmouth in the Shenandoah come July when the algae blooms are the heaviest have become thin and lethargic. Their fins droop and they don't fight when you pick them up. In the late 90's before I expanded my fishing out to other rivers in the state I thought that all smallmouth got sickly looking in the summer. We were also used to finding relatively high numbers of sick and dead fish in the Shenandoah even outside of the "normal" fish kill season in April – June. The fish were sick in the presence of a tremendously rich food base made up of legions of crayfish, schools of minnows and heavy terrestrial life. Smallmouth on all the other rivers I explored were robust, thick and healthy during the summer months. This was left unexplained by the scientists who didn't have the time to study it. I noted a very clear correlation between the level of algae growth in the river and the lethargy level of the fish, and their overall health..

What is MOST IMPORTANT about my life's fishing history and my professional career as a fishing guide was the fact that I made a living selecting the very best body of water in the Mid-Atlantic to take people fishing. This required that I have access to multiple sections of river, on multiple rivers in multiple states. My reputation and my success hinged on my ability to evaluate the physical conditions of the river including flow, water clarity and seasonal movements of fish to determine where I would take my clients through the ten month full time season.

This becomes very important in the context of our efforts to get the Shenandoah River listed as impaired due to loss of recreational use. Algae has a deep impact on both of those factors so fishing often hinged on whether or not algae was blooming in the Shenandoah. When the planktonic/pelagic algae blooms in the river it turns a thick pea green color and fish become lethargic, they don't find food effectively because they can't see and they reduce their feeding. Often fish have sores when you catch them. There is strong inverse correlation between the murkiness of the water and the number of fish that can be caught in a day. Murky water from an algae bloom meant poor fishing, every time.

The planktonic/pelagic algae has a deep affect on the enjoyment of fishermen beyond the drop in the quality of fishing. Fishermen were acutely aware when the algae was blooming due to the unpleasant look of the river, poor visibility, fish behavior/health and often odor as well. As a guide I would not purposefully guide a river that had a heavy planktonic/pelagic bloom and would spend my time working to avoid these conditions because it damaged the quality of the fishing day.

Additionally, when a planktonic bloom colored the water and decreased visibility there was no chance to see fish and narrow your search, observe their habitat or even to sight fish specifically to an individual fish.

An even greater threat to fisherman enjoyment on the Shenandoah are the colonial algae, which colonizes on the bottom substrate of the river and makes the river completely un-fishable. Our research shows the majority of these are toxin producing blue-green algae. This algae begins to colonize in April every year on the tops of rocks and rock ledges and as flows fall to normal summer levels they literally cover over between 50% and 100% of the bottom of the North Fork, South Fork and Main Stem Shenandoah. The algae grows a thick slimy layer which is dangerous and unpleasant to walk or wade on.

When algae has colonized the bottom of the river fishermen would complain that every single cast into the river end up fouled with the algae, the hook would gather frustrating clumps on your hook/lure/bait that literally had to be picked clean with your fingernails between casts. Fish literally will not eat your offering if there was so much as a tiny speck of algae on the hook/lure/bait. It has always been our belief that the algae makes the fish sick so they literally avoid getting it in their mouths. When the algae gets heavy fish will literally abandon vast areas of the river in favor of areas without algae growing. This greatly diminishes the amount of fishable miles of the river and confuses anglers when they literally can't find fish in their favorite holes any more. Many conclude the fish are dead. Sometimes they are dead. Fishermen often become depressed at the idea that there are only a few places they can catch fish in the river and don't understand

In addition, even for anglers using flies/lures/bait that floats or doesn't touch the bottom the colonized blue green algae still impede fishing. Every day when the algae photosynthesize they produce prolific gases which form bubbles on the surface of the algae and underneath the mats. Eventually the bubbles will lift a nearly infinite number of these chunks from the bottom and float them to the surface. On a bright sunny day it would not be unusual for this floating action to sour water clarity, but the worst part is that these floating mats cover the surface of the river. They look like human or animal feces. People mistake them for the this.

Riverkeeper Experiences

As Riverkeeper, we have spent significant time educating the public about the algae in the river. What we found when we surveyed users with an official survey form (attached) was that users had no idea what algae was. However they were very bothered by what they called snot grass, grass or in many cases manure balls. The users were deeply troubled by the coating of blue green algae on the bottom of the river and with few exceptions, mistook the masses of floating algae which had broken off the bottom and were floating to be manure, sewage or poultry litter. They noted the foul odor, the unsightliness and the interference with swimming and particularly fishing.

Many other users (approximately 25 complaints) complained to us about sewage odors and raw sewage spills or seeps. At first we would investigate the claims by visiting the river in the affected areas. The complaints almost always sounded like this "we were floating from point A to B, and when we passed X tributary or Y housing complex or Z poultry farm we began to see clumps of

feces on the surface of the river. The users always related the clumps of feces to a physical stationary feature on the bank. Noone knew in the beginning of our education campaign that the feces was actually blue-green algae.

What we learned upon investigation and eventually concluded is that the presence of those floating globs of feces were not related to a specific source. What was happening is that the algae would only begin to dislodge from the bottom to float to the surface during the noon/ afternoon period of the day when the algae was photosynthesizing oxygen. The river was saturated with oxygen during that narrow part of the day causing oxygen bubbles to form which floated these decaying mats of algae to the surface. Every user told us they were disgusted by the odor and alarmed by the idea that this substance threatened their health.

Since then I would estimate that we have received over 200 personal complaints about the algae.

XI. Qualifications of David Sligh

A. Statement

My name is David Sligh and I am qualified to present analyses and opinions on matters related to water quality monitoring and assessments, quality controls for monitoring data, water pollution, stream ecology, and investigative methods. My resume is included below at part B. of this Section but I offer some more specific information here about my background and abilities as they relate to the review performed in this Technical Report.

During my time in college, I worked for the Virginia State Water Control Board (“SWCB” or “the Board”), a predecessor agency to the Department of Environmental Quality, for two summers. This began a long series of jobs and advancements within the Water Board and the DEQ, where I was trained in many of the skills and began acquiring the knowledge I bring to this technical review.

After receiving my undergraduate degree in Environmental Science from the University of Virginia, I worked for the the SWCB in Roanoke on an EPA-funded monitoring study to assess runoff pollution problems and relative impacts from urban, suburban, agricultural, and forested watersheds. I helped plan and coordinate the sampling program, managed the data, performed a range of analyses, and co-wrote the final report for this study.

Next, I took a position in the Roanoke office where I compiled and analyzed all of the ambient water quality data for the region covered by our office. I wrote portions of the narrative for the agency’s 305(b) report and helped assemble the “priority water bodies list” - what is now generally known as the “impaired water list - under section 303(d) of the Clean Water Act.

I then received a promotion to a job where I conducted the first comprehensive review of all surface water monitoring activities by the Roanoke office. I documented the purposes of each sampling type and the individual locations and designed new protocols for monitoring parameters, schedules, and reporting. For this work, Ron Gregory, the Director of the Office of Water Quality Assessments for the Board, wrote that I had “pioneered the modernization of ambient water quality monitoring networks in Virginia” and noted that the methods I had developed were a model for changes made by regional offices around the state. Mr. Gregory also praised me for my “high level of competency” in the areas of aquatic ecology and limnology and for my knowledge of surface water monitoring programs and techniques, including quality assurance.

Finally, I served as a Senior Engineer for the SWCB and the DEQ, overseeing all aspects of permitting in the Roanoke region for NPDES facilities and land application operations. In this role I wrote requirements for stream studies for permitted parties and reviewed their proposals and results.

Since leaving the DEQ, I have worked in several non-profit organizations, where my knowledge of stream ecology and water quality studies has been very important. I was the representative in the Southeast U.S. for American Rivers. In this role I worked in six states on

both state and federal regulatory matters, served on technical advisory teams for river studies undertaken in relation to hydropower dam relicensing cases in North Carolina, Tennessee, Alabama, South Carolina, and Georgia. Later, I was Executive Director of the a local watershed group in Northeast Georgia. I supervised and helped conduct a watershed-wide water quality study with EPA funds. I also served as Upper James Riverkeeper and most recently have worked as a consultant for many non-profit groups. Among the projects I have completed are: reviews of NPDES permitted facilities in Maryland, reviewed and commented on the District of Columbia's bacterial TMDL, and designed a monitoring program to assess impacts on a watershed on the Eastern Shore of Maryland, where major poultry operations and other farming activities were present.

Throughout my state agency work and time with non-profit groups I have investigated many pollution complaints and sampled hundreds of streams, many in the Ridge and Valley, Blue Ridge, and Appalachian regions. I have testified in court and administrative hearings for the SWCB and DEQ as an expert on the types of issues addressed in this Technical Report. As well, I testified in a number of court proceedings for the Georgia River Network and Altamaha Riverkeeper in Georgia.

Two of the areas in which I believe my training and expertise are most applicable to the Shenandoah algae question are my familiarity with:

- * proper data gathering, quality control, and analyses and
- * my long experience applying Water Quality Standards, including those in Virginia and the southeaster states mentioned above, as well as in Vermont, Pennsylvania, D.C., and Maryland

I well understand the need for high quality data for the State of Virginia Integrated Report and listing of impaired waters and it is with that understanding that I comment upon the nature and quality of data that are presented by SRK in this case.

B. Resume

David Sligh
1433 Wickham Pond Drive
Charlottesville, Virginia 22901
434-964-7455
davidwsligh@yahoo.com

Education

Vermont Law School, South Royalton, VT - J.D. degree - 1999

Pertinent Courses: watershed protection (CWA), water resources law, law of toxic and hazardous substances (RCRA & CERCLA), air pollution law (CAA), general environmental law, land use planning, administrative law, legislation

Independent Study: analysis of states' applications of water quality standards provisions
- submitted as comments in response to EPA NOIRA

McNeese State University, Lake Charles, LA - Graduate course work in Biology - 1984

Pertinent Courses: ecology (focus on fish ecology in estuarine habitats), biochemistry

University of Virginia, Charlottesville, VA - B.A. degree in Environmental Science - 1982

Pertinent Courses: coastal and fluvial environments, hydrology, geology (field work in shoreline processes), fundamentals of ecology, applied ecology, forest ecology, aquatic chemistry, biology of fishes, tropical ecology

Independent Study: effects of low-flow conditions on the chemical, physical, and biological integrity, Roanoke River below Leesville Dam

Independent Study: trophic adaptations of marine benthic animals

Professional Qualification

Member of District of Columbia Bar

Employment

Environmental Consultant, Self-employed, Charlottesville, VA

Have completed projects including NPDES permit reviews, technical reviews of TMDLs, s. Clients include: Earthjustice, Gunpowder Riverkeeper, the Environmental Integrity Project, Miles-Wye Riverkeeper, and Shenandoah Riverkeeper.

Special Research Faculty, Virginia Tech,

Was assigned to the Virginia DEQ, to help develop and manage Annual Standards and Specifications program for compliance with Erosion & Sediment Control law and Stormwater Protection law, mandated by 2012 statutory changes. Conducted analysis of statute and regulations to ensure that requirements and fees are set appropriately for covered parties. Developed guidance for document preparation and conformance with legal requirements. Reviewed submitted documents for compliance.

Upper James Riverkeeper, James River Assoc., Charlottesville, VA

Protected the James River, its tributaries, and watershed through patrolling and monitoring, enforcement, involvement in regulatory matters, and education/motivation of citizens to act to improve and preserve their waters. Advocated and helped achieve improved regulation of poultry waste, industrial stormwater runoff, and construction stormwater pollution.

Executive Director, Soque River Watershed Assoc., Clarkesville, GA

Managed all programs, including a comprehensive, 3-year watershed study funded by the U.S. EPA and the State of Georgia. Supervised and conducted stream water sampling, benthic macroinvertebrate sampling, flow measurements, physical habitat assessments, and analyses of data.

Southeast Regional Representative, American Rivers, Chattanooga, Tennessee

Established regional office and led campaigns in TN, NC, SC, AL, GA, and VA. Advocated for river protection and restoration, through state and federal regulatory programs, news media, and education. Coordinated with and awarded/managed pass-through grants to state and local partners. Regularly served on technical and legal advisory committees, wrote and filed comments on studies and regulatory proposals. Consulted on technical and legal matters with partner environmental groups. Served as an expert witness on behalf of the Georgia River Network and the Altamaha Riverkeeper.

Adjunct Faculty Member, Univ. of Tennessee at Chattanooga

Taught environmental science.

Water Quality Assessment Assistant, Dept. of Environmental Conservation, Waterbury, Vermont (temporary job during law school)

Researched agency cases and files for data on pollution problems and conformance of programs with statutory and administrative mandates. Presented findings in state water quality assessment, impaired waterbodies listing, and legal and technical analyses of various programs.

Researcher, ARCS, Inc., Roanoke, Virginia

Researched energy trends and aerial pesticide spraying of power lines in West Virginia and Virginia and drafted formal submissions to Virginia State Corporation Commission. Prepared comments for U.S. Forest Service NEPA process regarding water quality and other issues. Lobbied state legislators to support citizen interests in state proceedings.

Senior Environmental Engineer, Virginia Dept. of Environmental Quality, Roanoke, Virginia,

Supervised division of engineers in: preparation of NPDES and Virginia Pollution Abatement permits (for land application of sludge and animal waste); analysis of environmental data and compliance records and preparation of enforcement documents; representation of agency at public hearings, negotiations, and in legal proceedings. Oversaw inspections of treatment facilities and land application operations, reviewed plans for special stream studies submitted by permit holders or applicants, completed stream models. Instructed environmental engineers under my supervision in technical, procedural, and legal matters associated with permitting processes.

Environmental Specialist, Virginia State Water Control Board

Coordinated all water quality research and monitoring activities in West Central region of state and designed new ambient monitoring system; prepared annual water quality reports on lakes program; conducted field surveys for benthic macro-invertebrates and water sampling; investigated pollution complaints and fish kills; prepared enforcement cases. Was the lead investigator in a landfill case, for which I testified in federal, state, and formal administrative court proceedings. Succeeded in closing the landfill, obtaining a judgement of \$1.4 million for damages and penalties, and provided evidence for criminal prosecution of owners.

Environmental Technician, Virginia State Water Control Board

Compiled and analyzed regional water quality monitoring data and co-authored Virginia Water Quality Assessment (CWA section 305(b) report); analyzed data and wrote portions of water quality and water supply plans.

Environmental Technician, Virginia State Water Control Board

Planned and coordinated year-long EPA-funded research program to assess water quality impacts from non-point source pollution/storm water runoff. Conducted interest group meetings and public meetings. Co-wrote final report.

Intern, Summers of 1980 and 1981, Virginia State Water Control Board

Conducted water quality studies and pollution investigations; compiled and analyzed facility compliance data.

Other Activities and Positions

Technical Advisory Committee to Tennessee Clean Water Network, 2000-2002
Legal Advisory Committee to Dogwood Alliance Board of Directors, 2002 - 2004
Steering Committee Member, Southeastern Imperiled Fish Network

Speaker at numerous conferences on water quality issues, including:

Chesapeake Watershed Forum, Shepherdstown, WV, 2011, 2012.
Waterkeeper Alliance Conferences, 2009, 2013.
When the Water Runs Dry, New Orleans, LA, 2003 (speaker and session leader).
The Future of Flows, Morgantown, WV, 2002.
National River Rally - River Network, 2001, 2002, 2013, 2014.
Georgia River Network Conferences, Milledgeville, GA, 2002 & 2003.
Alabama Rivers Alliance, Annual Conferences 2000, 2001.

VA. Coastal Zone Management Program

Water Control Board

Water Quality Standards

COASTAL ZONE
INFORMATION CENTER



Commonwealth of Virginia

TD224
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V58
1982

Publication No. RB-1-80

Revised Edition: April 1982

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INTRODUCTION

Basis and Purpose

The State Water Control Law mandates the protection of existing high quality State waters and provides for the restoration of all other State waters to such condition of quality that any such waters will permit all reasonable public uses and will support the propagation and growth of all aquatic life that might reasonably be expected to inhabit them (Section 62.1-44.2). The adoption of water quality standards under Section 62.1-44.15(3) of the Law is one of the Board's methods of accomplishing the Law's purpose.

Water quality standards consist of narrative statements that describe water quality requirements in general terms, and of numeric limits for specific physical, chemical or biological characteristics of water. These narrative statements and numeric limits describe water quality necessary to meet and maintain reasonable and beneficial uses such as swimming, public water supply and the propagation and growth of aquatic life. Standards include general, as well as specific, descriptions since not all requirements for water quality protection can be numerically defined. In those cases where numeric standards have not been formulated for scientific or practical reasons, the general standards establish broad requirements to protect and maintain beneficial uses of State waters. Standards are not static. They will change and be constantly adjusted to reflect changes in law, technology and information available to the Board and its staff.

Standards are used in the administration of several Board programs. One is the issuance of permits for the discharge of treated wastewater under requirements of both Federal and State law. Federal law (the Clean Water Act) mandates that certain minimum treatment levels be achieved by all dischargers. Before the Board issues a discharge permit, it must first determine if those minimum levels are sufficient to maintain water quality standards in the receiving stream. If not, the Agency formulates and enforces more-stringent permit requirements which will allow water quality standards to be met. The Board's 401 Certificate program also uses water quality standards. Under Section 401 of the Clean Water Act, if a Federal permit is needed by any project which will or may result in a discharge to State waters, the project must first receive certification from the appropriate State that the project will not violate water quality standards. The State Water Control Board is the 401 certifying agency in Virginia, and it judges whether or not water quality standards will be contravened by proposed projects in administering this certificate program.

Water quality standards are intended to protect the beneficial uses of State waters. Virginia's standards do not assign specific uses to all streams, although they do specifically designate and protect trout streams and public water supplies. The standards are intended to protect all State waters for recreational use and for the propagation and growth of a balanced population of fish and wildlife. By protecting these two uses, which usually require the most stringent standards and the highest degree of protection, other usually less restrictive uses like industrial water supply, irrigation and navigation are usually also protected. Should additional standards be needed to protect other uses as dictated by changing circumstances or improved knowledge, they can be formulated and adopted.

Background

From its beginning in 1946 until the mid 1960's, the State Water Control Board generally approached control of water quality problems on a case-by-case basis, frequently through the adoption of wastewater treatment requirements for individual watersheds. By the mid 1960's, however, the Board was beginning to recognize the need for a program of water quality control with a broader, more extensive base — one that would deal with actual in-stream water quality throughout the entire state.

The Federal "Water Quality Act of 1965" (PL-89-234), provided the incentive and framework for such a program by requiring the establishment of certain water quality standards on a local, state and national scale. States which did not, or could not, adopt standards would have such standards of water quality established by the Federal government. As a result of the Federal Act amendments, and under State law, the Board first developed and adopted water quality standards in 1966 through 1968. They were substantially amended in 1970.

The 1972 amendments to the Federal Water Pollution Control Act (PL-92-500), restated the concept of water quality standards, and set certain water quality goals such as the attainment, by July 1, 1983, of water quality which provides for protection of fish, shellfish, and wildlife and for recreation in and on the water. In 1973 Virginia's water quality standards were slightly amended to ensure compliance with these aims.

This Act further required that a state's water quality standards be reviewed at least once every three years and, as appropriate, modified or amended. Virginia has completed one review period through public hearings in 1976 and formal adoption of amendments in 1977. The present standards have received Federal (Environmental Protection Agency) approvals required by the Act.

Development and Adoption

In order for water quality standards to be realistic while at the same time serving the stated purpose of maintaining or improving water quality, there first must be established a relationship between the standard itself and the benefit to be derived from adoption and enforcement of the standard. This relationship is generally determined by making certain studies, or evaluating already completed studies that define or attempt to define which standards and limits are required to provide needed levels of protection for certain water uses. A decision is then made regarding what levels of protection are desired. Finally, the appropriate standards and limits are chosen in order to provide the desired level of protection.

There are many sources of information or studies useful in the development of standards, and from time to time studies are conducted as needed by the Board or by consultants under contract to the Board. A major source of information is the publication *Quality Criteria for Water* published by the United States Environmental Protection Agency in 1976, pursuant to the requirements of the 1972 amendments to the Federal Water Pollution Control Act.

Since standards are designed to protect specific uses, the need for new or amended standards often comes about as a result of an identified new use of a body of water. For example, the Commission of Game and Inland Fisheries may identify a stream which was previously not known to support trout, as a natural trout stream. In this case the standards may be modified to protect this particular use. Also, a locality might want to use a stream as a water supply, and if the stream was not already classified as a public water supply, new standards would have to be applied to protect this use.

Information from every segment of the population is helpful in the development of standards, and their adoption can have wide-ranging effects. Public participation at all levels of standards development is therefore important to the adoption and implementation of standards which reflect the desire of the general public. The Law requires opportunity for public participation in the adoption of standards. Accordingly a public hearing with adequate public notice is mandatory before any standard can be adopted, amended, or cancelled. Following public notice of the hearing, the public has an opportunity to study the proposed standard and determine its effects. At the public hearing any person who is either for or against the proposed Board action on the standard may state his interest in the matter and enter relevant evidence into the hearing record.

Recent amendments to State Law added another mandatory consideration relative to standards — that the Board must give ample consideration to social and economic costs and benefits which will result from any action on the standard, whether by adoption, modification or cancellation.

Following the public hearing the Board's staff examines the hearing record, makes recommendations, and submits both the record and the recommendations to the Board for its consideration and action. Board action on a standard becomes effective thirty (30) days after filing with the Registrar of Regulations who keeps all standards and regulations of State agencies on file.

Both Federal and State legislators recognized the need for periodic review of all standards, and now both Federal and State law require that standards be reviewed at least every three years for possible changes and that the Board hold sufficient public hearings for public input. The Board is required to modify or cancel these standards, or to adopt new ones, as needed.

Summary and Explanation of Contents

This booklet contains the following seven sections:

1. Standards with General State-wide Application (Pages 5-11)

These standards apply to waters on a State-wide basis and include such things as the General Standard, dissolved oxygen and temperature standards for surface waters, and groundwater standards.

2. Standards with More Specific Application (Pages 12-14)

These standards have a specific application; they include, for example standards for public water supplies.

3. Procedural Requirements (Pages 14-15)

This section includes rules that are a part of the standards such as a rule specifying acceptable analytical procedures for water testing.

4. River Basin Section Tables (Pages 15-65)

This section divides the State's nine river basins into sections and indicates what specific standards apply to these specific sections.

5. Key to Special Standards (Pages 67-75)

This section contains the entire printing of special standards that were too long to include in the tables of Section 4.

6. Water Quality Criteria (Pages 76-78)

This section includes information about levels of pollutants to protect surface water and groundwater quality; they are not standards.

7. River Basin Maps (Plates 1-13)

Maps in this part of the booklet delineate the river basin sections described in Section 4.

Additional more specific information can be found in the individual parts of the booklet.

In order to find applicable standards for a surface stream, first one must determine what River Basin Section the stream is in. This may be determined directly from the River Basin Section Tables or it may be necessary to determine the section by using the maps in Section 7.

The River Basin Section Tables indicate each section's Classification (Roman numeral I through VI). Paragraph 1.04 contains the standards that apply to the particular class and paragraphs 1.05 - 1.07 indicate other standards. The River Basin Section Tables also indicate whether any Special Standards apply to the stream. The entire special standard is printed in the special standards column if short; otherwise, a letter in the Special Standards Column refers the reader to the Special Standard which can be found in the Key to Special Standards Section, Section 5, beginning on page 67.

To determine applicable groundwater standards for an area, one can determine which physiographic province the area is in by checking Figure 1 on page 11, then by referring to the standards in Paragraph 1.09 on pages 9-10 that apply to that physiographic province.

In the sections that follow, all standards are shown in boldface type both in text and in tables. The text in lightface type preceding such standards is generally specific explanatory information relating to the standards that follow.

Information Concerning 2014 Clean Water Act Sections 303(d), 305(b) and 314 Integrated Reporting and Listing Decisions

- [MEMORANDUM](#)
- [Enclosure](#)
- 1. [Timeliness of State Integrated Report \(IR\) submissions and EPA approval](#)
- 2. [Recommendations for the appropriate consideration of Natural Conditions to support removing a water from or not including a water on the 303\(d\) list](#)
- 3. [Potential approaches for identifying nutrient-related impaired waters for the 303\(d\) list based on narrative nutrient water quality criteria and/or direct evidence of failure to support designated uses](#)
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, D.C. 20460

OFFICE OF WATER

September 3, 2013

MEMORANDUM

SUBJECT: Information Concerning 2014 Clean Water Act Sections 303(d), 305(b), and 314 Integrated Reporting and Listing Decisions

FROM: Denise Keehner, Director /s/
Office of Wetlands, Oceans, and Watersheds

TO: Water Division Directors, Regions 1 – 10
Robert Maxfield, Director, Office of Environmental Measurement and Evaluation, Region 1

I am pleased to provide you with information to assist you and your States as you prepare and review the 2014 Integrated Reports (IR), in accordance with Clean Water Action (CWA) Sections 303(d), 305(b), and 314. This memorandum focuses on: 1) timeliness of State IR submissions and EPA approvals, 2) recommendations for the appropriate consideration of Natural Conditions in listing decisions, 3) potential approaches for the identification of nutrient-related impaired waters for the 303(d) list based on narrative nutrient water quality criteria and/or direct evidence of failure to support designated uses, 4) an update on tools and formats for submitting IR data to EPA – Assessment and Total Maximum Daily Load Tracking and Implementation System (ATTAINS), and 5) an update on EPA's development of guidance on how States can address antidegradation policies and procedures in their Section 303(d) programs. In addition, EPA will continue to work with the States and Regions in the coming months to identify any issues that may necessitate further clarification in future reporting cycles.

Over the past year, EPA and the States have developed a Long-Term Vision and Goals for assessment, restoration, and protection under the CWA Section 303(d) Program, which was endorsed by the Association of Clean Water Administrators. The development of a new long-term vision was an important element of the program's evolution and will better prepare and align efforts under the program to address current and future challenges and opportunities for protecting and restoring water quality. As part of this effort, EPA and the States developed six goal statements with milestones for completion: prioritization (2016), assessment (2020), protection (2016), alternatives (2018), engagement (2014), and integration (2016). EPA and the States intend to carry out this Vision and associated goals consistent with a more detailed implementation plan.

In addition, EPA and the States continue to make progress on the Integrated Reporting Georeferencing Pilot. As geospatial data and technology have evolved, EPA continues to seek efficiencies and improvements in the georeferencing of State water quality assessment and impairment decisions at the federal level. It is anticipated that this effort will be finalized by the end of 2013.

This memorandum is not regulation and does not impose legally binding requirements on EPA or the States. EPA recommends that the States prepare their 2014 IRs consistent with previous IR guidance including EPA's 2006 IR Guidance, which is supplemented by EPA's 2008, 2010, and 2012 IR memos and this memorandum available at [EPA Guidance](#).

I would like to thank our State partners, interstate commissions, and Regions for their input on the information in this enclosure. I particularly appreciate the continued hard work and dedication in developing the IRs so that we can report to the public on the status of the nation's waters. If you

have any questions or comments concerning this memorandum, please contact me or have your staff contact Shera Reems at 202-566-1264 or reems.shera@epa.gov.

Enclosure

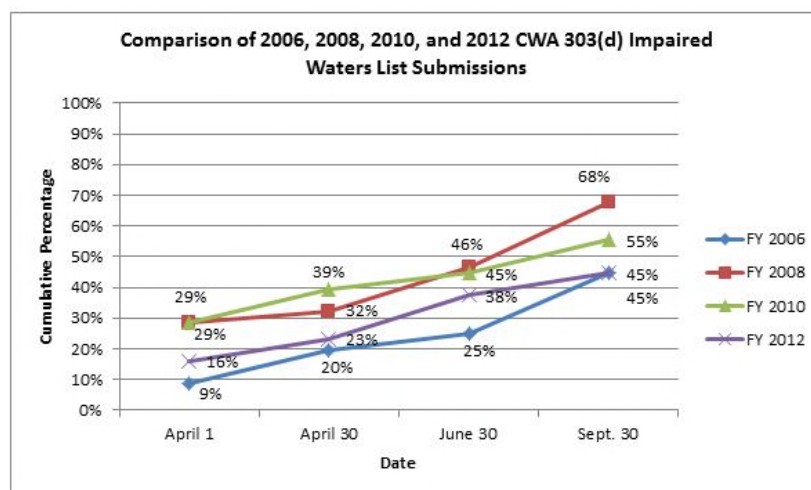
cc: Regional Section 303(d) Coordinators
Regional Monitoring Coordinators
Regional Water Quality Standards Coordinators
Regional NPDES Coordinators
Alexandra Dunn, Association of Clean Water Administrators

INFORMATION CONCERNING 2014 CLEAN WATER ACT SECTIONS 303(d), 305(b), AND 314 INTEGRATED REPORTING AND LISTING DECISIONS

1. Timeliness of State Integrated Report (IR) submissions and EPA action on State Section 303(d) lists.

The U.S. Environmental Protection Agency (EPA) and States need to continue best efforts to provide on-time State Integrated Report (IR) submittals (all 56 States and Territories by April 1, 2014) and EPA action on the States' Clean Water Act (CWA) Section 303(d) lists (within 30 days of their submission). While EPA and the States made progress from the 2006 to the 2008 reporting cycle, this progress did not continue with the 2010 and 2012 reporting cycles. For the 2008 reporting cycle, 38 States submitted their IRs by the end of the fiscal year compared to 31 for the 2010 reporting cycle and 25 for the 2012 reporting cycle (see Figure 1). Also, EPA action on States' Section 303(d) lists continues to fall short of the progress made in the 2008 reporting cycle. For the 2012 reporting cycle, of the 25 lists submitted to EPA by the end of FY 2012, EPA had taken action on only 15 lists as of the end of the calendar year, and these lists took an average of 53 days to approve. This average will be significantly higher once all 303(d) lists are approved. Timely State submittal of IRs and EPA review and approval or disapproval of lists is central to meet EPA and State responsibilities under the CWA and to evaluate EPA and State success in accomplishing our strategic plan goals to restore and maintain the nation's waters.

Figure 1: Timeliness of State 2006, 2008, 2010, and 2012 IR Submissions



EPA recognizes that State resources to complete these actions are limited. Hence, both EPA and the States need to continue best practices to provide timely information on the status of the nation's waters, including the State identification of waters under Section 303(d)(1)(A) of the CWA. Such Section 303(d) lists consist of "water quality limited" waters (i.e., waters that fail to meet one or more applicable water quality standard). In the 2008 IR Memo,¹ "Information Concerning 2008 Clean Water Act Sections 303(d), 305(b), and 314 Integrated Reporting and Listing Decisions," EPA outlined several best practices used by States and Regions to help facilitate improved timeliness of submission and review of water quality reports and Section 303(d) lists. We recommend that States and Regions refer back to these best practices and identify areas in which it is feasible to make improvements.

As an outcome of the EPA and State effort to identify opportunities to reduce State reporting burden under CWA Sections 303(d) and 305(b)², EPA will soon provide additional recommendations to move toward more timely IR submittals and EPA review and approval or disapproval of 303(d) lists. One driver for this effort was a request by a number of States for EPA to evaluate whether a change in reporting frequency from two years to four or five years would reduce State burden. EPA commenced a series of meetings with State partners that first identified key steps in the IR process, followed by discussions focused on those steps requiring the highest level of effort by States. These steps included: 1) State review and use of available data to make assessment decisions, 2) State preparation of data and associated geospatial information and entry into an assessment database, 3) State preparation and submission of final Section 303(d) lists and 305(b) reports to EPA, and other relevant documentation, 4) State preparation or refinement of its assessment and listing methodology, and 5) State response to public comments. During each discussion, EPA

requested State input on a series of questions, including how a change in reporting frequency would help or not help alleviate State burden. At the conclusion of these meetings, while a few States indicated that EPA should lengthen the reporting cycle, the majority of States recommended that EPA not change the length of the reporting cycle. EPA and the States did identify several areas within the existing framework as good candidates for streamlining to improve the efficiency of assessment, listing, and reporting. In addition to this effort described above, EPA is currently working to identify opportunities to maximize efficiencies and streamline EPA's Section 303(d) list review process.

1. [Information Concerning 2008 Clean Water Act Sections 303\(d\), 305\(b\), and 314 Integrated Reporting and Listing Decisions](#)
2. Undertaken pursuant to Executive Order 13563 "Improving Regulations and Regulatory Review"

2. Recommendations for the appropriate consideration of Natural Conditions to support removing a water from or not including a water on the Section 303(d) list

In the 2006 IR Guidance, "Guidance for 2006 Assessment, Listing, and Reporting Requirements Pursuant to Sections 303(d), 305(b), and 314 of the Clean Water Act," and the 2008 IR Memo, "Information Concerning 2008 Clean Water Act Sections 303(d), 305(b), and 314 Integrated Reporting and Listing Decisions," EPA provided information on the role of natural conditions concentrations of pollutants in 303(d) listing decisions.

EPA stated that applicable water quality standards are the basis for determining whether a waterbody must be included on a State's Section 303(d) list. States may have approved natural conditions provisions in EPA approved water quality standards that specify the applicable aquatic life water quality criterion will be equal to the natural conditions level of a pollutant if it is determined that the natural conditions does not meet the otherwise applicable criteria. In the absence of an EPA-approved natural conditions provision or an EPA-approved site-specific criterion based on natural conditions, the otherwise applicable criterion is the basis for determining whether a waterbody belongs on the State's Section 303(d) list.

EPA's guidance on the appropriate use of natural conditions provisions for making 303(d) listing decisions remains unchanged for the 2014 reporting cycle. For example, as discussed in the EPA IR guidance for the 2006 and 2008 reporting cycles, if a State has an EPA-approved natural conditions provision or site-specific criterion based on natural conditions, it may use these as the basis for determining if a water should be included on a State's Section 303(d) list. When a State evaluates whether a potential designated use impairment is the result of natural conditions, the State should consider all sources of the pollutant being evaluated. If the pollutant concentrations do not meet the EPA-approved water quality standards, and anthropogenic sources of the pollutant are present, the water is considered impaired and should be included on the State's Section 303(d) list even if natural sources of the pollutant are present. In the 2008 IR Memo, EPA provided several theoretical examples to illustrate these recommended approaches; however, note that these examples do not address all possible scenarios or variations in EPA-approved water quality standards. In addition, EPA continues to support its statement that natural conditions provisions are not appropriate for human health criteria. For more information see, "[Establishing Site Specific Aquatic Life Criteria Equal to Natural Background \(PDF\)](#)" (3 pp, 125K, [About PDF](#)).

If a State determines that a water fails to meet an applicable water quality standard solely due to naturally occurring levels of a pollutant, and it has an approved applicable natural conditions provision, the State should include in its IR submission for the 2014 and future reporting cycles a rationale for either removing or not including the water/pollutant combination on the State's Section 303(d) list. The rationale should identify the geologic or other conditions that cause the natural loading of the pollutant to exceed otherwise applicable water quality standards. In addition, the rationale should document why anthropogenic sources of pollutant loading, such as municipal, industrial, agricultural, contaminated groundwater, or anthropogenic airborne deposition, were determined not to be sources of pollutant loading. The rationale should also cite the approved, applicable natural conditions provision upon which the State is relying. Including this rationale will provide interested stakeholders with a more complete understanding of the State's use of its natural conditions provision and help expedite EPA's review of the State's IR submission.

More information on EPA's existing guidance on the use of natural conditions provisions for making Section 303(d) listing decisions is available at [Guidance for 2006 Assessment, Listing, and Reporting Requirements Pursuant to Sections 303\(d\), 305\(b\), and 314 of the Clean Water Act](#) and [Information Concerning 2008 Clean Water Act Sections 303\(d\), 305\(b\), and 314 Integrated Reporting and Listing Decisions](#).

3. Identifying nutrient-impacted waters for the Section 303(d) list for States without numeric nutrient water quality criteria

Addressing nutrient pollution in our nation's waters is one of EPA's top priorities. Over the past decade EPA has called upon the States and others to increase their efforts to address nutrient pollution. In a March 2011 memorandum to the States, tribes and territories, EPA reiterated the need for action by stating, "*States, EPA, and stakeholders, working in partnership, must make greater progress in accelerating the reduction of nitrogen and phosphorus loadings to our nation's waters.*"

National monitoring efforts, such as USGS reports on surface water quality³ and EPA's National Aquatic Resource Surveys,⁴ document the widespread impacts of nutrients on our nation's waters. A USGS report examining changes in nutrient concentrations at selected sites monitored between 1993 and 2003 indicates increasing levels of nutrients at about one-third of the sampled sites. EPA's National Aquatic Resource Surveys (NARS) report that nutrients are a widespread problem. NARS, often referred to as probability-based surveys, provide nationally consistent and scientifically-defensible assessments of our nation's waters and can be used to track changes in condition over time. Each survey uses standardized field and laboratory methods and is designed to yield unbiased estimates of the condition of the whole water resource being studied (i.e., rivers and streams, lakes, wetlands, or coastal waters). Based on completed survey results, about 50% of the nation's streams and 45% of the nation's lakes are in fair to poor condition for nitrogen or phosphorus levels relative to reference condition waters. This translates to about 300,000 miles of

perennial streams and seven million acres of lakes across the U.S. The analyses show that when streams and lakes rate poor for excess levels of nitrogen and phosphorus they are twice as likely to have poor biological health based on benthic macroinvertebrate condition.

While the NARS probability-based results are not directly comparable to the national tally of segment-specific waters included on States' Section 303(d) lists, it is helpful to consider the magnitude of the differences between the two regarding the effects of nutrients. Based on information submitted by the States, about 155,000 miles of rivers and streams and about four million acres of lakes are included on States' Section 303(d) lists for nutrients or nutrient-related impairment causes.^{5,6} EPA expects States will consider the NARS findings to increase efforts to identify and manage nutrient pollution. The NARS raw data as well as data in EPA's STORET database are available at the [Water Quality Portal](#). These data can be used, along with other existing and readily available data and information, to evaluate whether waters are meeting applicable water quality standards including designated uses, narrative and numeric criteria, and antidegradation policies. These findings could also be used to set monitoring priorities to generate sufficient data and analyses to identify and manage nutrient pollution. As States gain experience implementing State scale statistical surveys to complement the targeted monitoring, they will be in a position to use such surveys as a feedback mechanism to gauge completeness of the Section 303(d) list and effectiveness of overall efforts to reduce nutrient pollution.

The CWA and EPA's implementing regulations require States to identify water-quality limited segments still requiring TMDLs where pollution controls are not stringent enough to meet any applicable water quality standard. Applicable water quality standards include designated uses and the criteria that must be met to support the uses as well as antidegradation requirements.⁷ Furthermore, if a designated use is not supported and the segment currently fails to meet an applicable water quality standard or is "threatened," it must be included on the State's Section 303(d) list even if the specific pollutant causing the water quality standard exceedance is not known at the time.

Lack of numeric criteria for nitrogen and phosphorus adopted into State water quality standards and/or an inability to readily apply narrative criteria are sometimes cited as reasons for not assessing or including waters on States' Section 303(d) lists for nutrient-related impairments of designated uses. A number of States have listed waterbodies for nutrients and nutrient-related impacts based on a range of methods starting from simple visual assessments to straightforward decision matrices to more complicated stressor ID analyses.

Listing Approaches

A State can determine whether a waterbody is attaining its applicable narrative nutrient or other relevant narrative criteria and designated uses by using results of visual assessments. For example, field observations of excessive algal growth, macrophyte proliferation, adverse impacts on native vegetation (e.g., eelgrass), presence or duration of harmful algal blooms, unsightly green slimes or water column color, and/or objectionable odors may be a basis to include a waterbody on the State's Section 303(d) list for failing to meet one or more applicable narrative criteria and designated uses.⁸

A State can also place a waterbody on its Section 303(d) list by using other existing and readily available water quality-related information from local, State, or federal agencies, members of the general public, or academic institutions.⁹ Evidence of narrative criteria and/or designated use impairment can include documentation of fish kills (aquatic life use) and beach closures or outbreaks of waterborne illness among swimmers (recreational use). A particular case of the latter related to nutrients is illness resulting from blooms of toxic blue-green algae (cyanobacteria). States should also consider feedback from the general public and waterbody users about the condition of the waterbody such as photographs or testimonials of abundant algal mats that impede recreation or create unsightly aesthetics in the waterbody.

It is important to note, however, that lack of plant growth or other visual pieces of evidence is not a reason to exclude or delist a waterbody for nutrient pollution as a cause of impairment where nutrient levels are elevated because other factors may be masking the nutrient response.

Another approach to assessing waterbodies is to evaluate nitrogen and phosphorus data sets derived from water column samples. For instance, some States have developed numeric water quality targets or thresholds for nitrogen and/or phosphorus that are used as quantitative "translations" of their narrative criteria. Unlike EPA approved water quality standards containing numeric nutrient criteria, the nitrogen and phosphorus target values are often described in State guidance or methodology documents. A State can also use the numeric target values in combination with measurements, such as dissolved oxygen, pH and/or chlorophyll-*a* (or other nutrient pollution response parameters), to reach a nutrient-related cause of impairment when implementing their narrative criteria.

Some States complete stressor identification analysis aimed at determining whether nutrients caused or contributed to the failure to meet the narrative criteria. Often, the stressor ID methods involve using multiple lines of evidence, including information on the causal variables (e.g., total nitrogen or total phosphorus) and response indicators (e.g., chlorophyll-*a*, dissolved oxygen, pH, macroinvertebrates, periphyton). States may set benchmarks, weigh particular indicators, or invoke statistical analyses using confidence levels. Some States use a step-wise or tiered approach. States employing the tiered approach often identify a set of core parameters on which to base their evaluation. Depending on the number of indicators that exceed threshold values (weighted or unweighted), the final assessment invokes secondary and sometimes tertiary parameters.

Because nutrients increase the overall productivity of a waterbody, biological information can provide an important clue into nutrient impairment, and a number of States include some kind of biological assessment as one of the lines of evidence when assessing whether a waterbody is meeting its narrative criterion. Data on macrophyte cover, chlorophyll-*a*, algae assemblages, including diatoms, are used to gauge the biological condition of the water. Biological condition is often measured using an Index of Biological Integrity (IBI), Observed/Expected (O/E) models, and other analytical techniques. When making decisions regarding impairments related to nutrient pollution, it is important to use information on biological endpoints that

are sensitive to increased concentrations of nutrients. Linking nutrients to the biological response can be done via stressor identification, multiple lines of evidence, or other means. Additionally, some States have used biological information independently and will list the source of the biological impairment in the "unknown" category until the stressor-ID or TMDL analysis determines the pollutant of concern.

To assist States, EPA is providing a number of examples of approaches that can be used for assessing whether waters are attaining nutrient-related narrative criteria and/or supporting designated uses. These examples are presented to inform States that have not yet established nutrient assessment methods for applicable narrative criteria and to illustrate how some States assess their waters pending the adoption of numeric nutrient criteria.

EPA does not endorse one method over another, nor does it limit potentially acceptable methods to those provided here. Likewise, the appropriateness of a particular method will depend on the variety of fact-specific circumstances that may be present.

3. [USGS Circular 1350: Nutrients in the Nation's Streams and Groundwater](#)
4. [National Aquatic Resource Surveys](#)
5. For purposes of presenting State information in ATTAINS, EPA compiles State reported impairments into national category groups, and as such, EPA defines "nutrient-related" as impairments that fall under the following parent category groups: nutrients, organic enrichment/oxygen depletion, ammonia, algal growth, and noxious aquatic plants. See [Water Quality Assessment and Total Maximum Daily Loads Information](#)
6. Based on the most recent data available in ATTAINS for each State, the sum of the size reported for unique assessment units that are identified as impaired (i.e., either on a State's Section 303(d) list or have an approved TMDL for rivers and streams and lakes). Information was pulled for only nutrient-related national categories, defined as impairments that fall under the following parent category groups: nutrients, organic enrichment/oxygen depletion, ammonia, algal growth, and noxious aquatic plants. See [Water Quality Assessment and Total Maximum Daily Loads Information](#). For 303(d) data, size is an optional field, and several waters did not have size information. Therefore, this information likely underestimates the extent of the nutrient problem across the nation. (accessed: January 14, 2013)
7. EPA's 303(d) listing regulations at 40 CFR 130.7(b)(3) define a "water quality standard applicable to such waters" and "applicable water quality standards" as "those water quality standards established under 303 of the Act, including numeric criteria, narrative criteria, waterbody uses, and antidegradation requirements."
8. Specific listing decisions depend on the particular language provided in a State's narrative criteria or designated use description.
9. 40 C.F.R. Section 130.7(b)(5) requires that each State assemble and evaluate "all existing and readily available" water quality-related data and information, which "at a minimum," includes water quality problems that have been reported by local, state, or federal agencies, members of the public, or academic institutions.

State Examples of Section 303(d) Listing Approaches for Nutrient-related Narrative Criteria

Oregon

Narrative Criterion: For all surface waters, the development of fungi or other growths having deleterious effect on stream bottoms, fish or other aquatic life, or that are injurious to health, recreation, or industry may not be allowed.

- Oregon has placed waters on the Section 303(d) list based on health advisories. Specifically, these health advisories are issued by the Oregon Department of Human Services, in conjunction with other agencies, warning that potentially harmful levels of cyanotoxins produced by algae are present in the water. The health advisories are based on visible scum, with supporting photographs and water analysis, cell counts or toxicity levels, or a combination of two or more options. The advisories apply to several designated uses, including domestic and industrial water supply, irrigation livestock watering, fish and aquatic life, fishing, boating, contact recreation, and aesthetic quality. Additional details on the State's assessment method and the health advisory protocol are available at: [Methodology for Oregon's 2010 Water Quality Report And List of Water Quality Limited Waters \(PDF\)](#) (88 pp, 1.2MB, [About PDF](#)) and [Harmful Algae Blooms \(PDF\)](#) (88 pp, 1.2MB, [About PDF](#))

Vermont

Narrative Criterion: In all waters, total phosphorus loadings shall be limited so that they will not contribute to the acceleration of eutrophication or the stimulation of the growth of aquatic biota in a manner that prevents the full support of uses. In all waters nitrates shall be limited so that they will not contribute to the acceleration of eutrophication, or the stimulation of the growth of aquatic biota, in a manner that prevents the full support of uses.

- Vermont uses public feedback and complaints in addition to field surveys of algae blooms to assess waters for attainment of the above water quality standard. For the swimming/contact recreation use in lakes, waters are considered impaired if an ongoing record of public complaint concerning the algal conditions in the water has been established. For cyanobacteria (blue-green algae), waters displaying ongoing summer blooms of toxin producing cyanobacteria and having microcystin concentrations at elevated levels (i.e., World Health Organization (WHO) guideline of 1 µg/l) are considered impaired. For the drinking water supply use, waters are considered impaired if they display ongoing summer blooms of toxin producing cyanobacteria and have microcystin concentrations in excess of the same WHO guideline above. Additional details on the State's assessment method are available at: [Vermont Surface Water Assessment and Listing Methodology \(PDF\)](#) (34 pp, 675K, [About PDF](#))

Montana

Narrative Criterion: State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will...create conditions which produce undesirable aquatic life.

- Montana's assessment method to address nitrogen and phosphorus pollution for Wadeable streams includes an "overwhelming evidence of nutrient impairment" provision for which photo documentation is adequate to make an impairment determination for aquatic life use. The State defines overwhelming evidence of nutrient impairment as either fish kills that involve massive growths of senescing algae mats (bottom attached or floating) or stream beds covered with filamentous algal growth for a substantial distance. Sample photos and more details can be found in [Montana's Assessment Methodology for Determining Wadeable Stream Impairment Due to Excess Nitrogen and Phosphorus](#) [REDACTED].

Delaware

Narrative Criterion: *Waters shall be free from...any pollutants that may impart undesirable...colors to the water or to aquatic life found therein, may endanger public health, or may result in dominance of nuisance species.*

- The State's 2010 assessment methodology includes numeric water quality targets for nitrogen and phosphorus in guidance that can be used for the majority of waterbody types in the State as a basis for Section 303(d) listing for aquatic life use. Additional details are available at: [State of Delaware 2010 Combined Watershed Assessment Report \(305\(b\)\) and Determination for the Clean Water Act Section 303\(d\) List of Waters Needing TMDLs \(PDF\)](#) (165 pp, 4.4MB, [About PDF](#)) [REDACTED].

Iowa

Narrative Criterion: *Waters shall be free from materials attributable to wastewater discharges or agricultural practices producing objectionable color, odor, or other aesthetically objectionable conditions.*

- Iowa uses Trophic State Index (TSI) values for chlorophyll-*a* and Secchi depth as a basis for Section 303(d) listing (i.e., "aesthetically objectionable condition") for primary contact recreation for lakes. Under a different narrative criterion, the State also uses TSI values for chlorophyll-*a* or total suspended solids concentrations to assess aquatic life use support in shallow lakes. Additional details on both assessment methods are available at: [Methodology for Iowa's 2012 Water Quality Assessment, Listing, and Reporting Pursuant to Sections 305\(b\) and 303\(d\) of the Federal Clean Water Act \(PDF\)](#) (155 pp, 4.4MB, [About PDF](#)) [REDACTED].

New Mexico

Narrative Criterion: *Plant nutrients from other than natural causes¹⁰ shall not be present in concentrations that will produce undesirable aquatic life or result in a dominance of nuisance species in surface waters of the state.*

- New Mexico uses a two-tiered approach to assess whether Wadeable, perennial streams are attaining the State's narrative nutrient criterion and support aquatic life use. Both stressor and response variables are used in two sequential levels of assessment to determine if the State's narrative criterion is attained.

The Level I assessment is a screening evaluation and based on a review of available data, including on-site observation (i.e., percent algal cover, periphyton growth, and presence of anoxic layer) and in-stream measurement (i.e., total nitrogen, total phosphorus, dissolved oxygen, and pH) indicators. Except for pH, all of the thresholds for these indicators are provided in the State's listing guidance. The threshold for pH is a separate State water quality standard. If two or more Level I indicators exceed their Level 1 thresholds, a Level II assessment is subsequently used.

The Level II assessment uses a multiple lines of evidence approach to take into account diverse lotic systems. This level of the assessment uses a more robust set of measurements for both stressor (percent total nitrogen and total phosphorus concentrations above threshold concentrations) and response (diel fluctuations of dissolved oxygen and pH, and chlorophyll-*a* (µg/cm²) variables).

A waterbody is considered not attaining the narrative criterion if at least one causal variable and one response variable exceed thresholds in the Level II assessment. More information is available at: [Nutrient Criteria Development](#) [REDACTED].

10. New Mexico has an additional stand-alone provision for natural conditions in their water quality regulations.

Moving Forward to Improve Section 303(d) Listing Programs for Nutrients

EPA strongly encourages States to evaluate the status of their waters with respect to nutrient pollution and to add to their Section 303(d) list waters failing to meet applicable nutrient-related narrative criteria or waters with evidence of unsupported designated uses. For those States that have developed nutrient-related assessment methodologies, EPA anticipates that they will continue to improve their efforts and enhance their nutrient assessment programs. For States without nutrient-related assessment methodologies, EPA is providing the above examples to demonstrate the flexibility States have to develop nutrient-related assessment methodologies based on applicable narrative criteria pending the completion of numeric nutrient criteria.

To facilitate stakeholder input and EPA review of States' Section 303(d) lists, States are encouraged to describe or reference in their assessment methods the rationale for selecting the approach and associated threshold levels for the stressor and/or response parameters used to translate the narrative criteria. In addition, States may need to consider updating their monitoring protocols to address any new or modified stressor and/or response parameter used in the methodology.

As discussed in the 2006 IRG, States should also include in their assessment methods their data quality, quantity, and representativeness expectations and protocols for making water quality attainment determinations. Such expectations are particularly important when information from stakeholders can be used to assess whether applicable water quality standards are being met. For example, to facilitate a timely submittal of States' Section 303(d) lists and EPA review, States should consider including expectations that stakeholder data and information (e.g., waterbody user testimonials and photographs of waterbody conditions) include supporting information such as the date, specific location, and period of time that the waterbody condition was observed. Regarding location, States should also consider making available to the public information about their waterbody segmentation approach to facilitate stakeholders' ability to associate the observations with specific waterbody segments if more specific geographic measurement tools (e.g., hand held geographic positioning systems) are not available. The protocols should be published along with any solicitation for data and information. Ideally, such QA/QC protocols should be made available to the public in advance of any such solicitation for any given IR cycle. As a general matter, the protocols should strike a balance between employing only the very highest quality data and information and employing the most useful information about the conditions of as many segments as possible. Additional details on EPA's previous guidance regarding data quality, quantity, and representativeness considerations for making Section 303(d) listing decisions are available at: [2006 Integrated Report Guidance](#).

When States do not evaluate all existing and readily available data and information relevant to applicable narrative criteria and designated uses or fail to provide a rationale for not using certain existing and readily available data or information, EPA will take appropriate actions consistent with the CWA.¹¹ For example, in 2010, one State modified its assessment methods to make attainment decisions based on numeric criteria only and removed from the list a number of lakes originally listed for not attaining the State's narrative nutrient criterion based on trophic conditions. EPA conducted an independent analysis of available data for each lake removed from the State's Section 303(d) list and concluded that 12 of the lakes should be added to the State's Section 303(d) list based on not meeting the narrative nutrient criterion.

Together, EPA and its State partners are responsible for achieving the goals of the CWA to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Thus, EPA encourages States to renew their efforts to identify those waters impaired by nutrient pollution that are not meeting applicable water quality standards.

11. See 40 CFR 130.7(d)(2)

4. Assessment and Total Maximum Daily Load (TMDL) Tracking and Implementation System (ATTAINS)

As discussed in the 2012 IR Memo,¹² IR data include State water quality assessment decisions, attribute data, and the geospatial data representing the geographic locations of those assessed waters. This information is needed in order for EPA and the public to better understand the status of the nation's waters. EPA's ATTAINS database¹³ is the repository for State IR attribute data, and the Reach Address Database¹⁴ contains State IR geospatial data. EPA compiles State-submitted IR data to develop and publish the National Water Quality Inventory Report to Congress (CWA Section 305(b)), determine States' variable portion of the Section 106 grant allocation formula, inform water quality decisions, and to conduct national analyses with various stakeholders to help restore the nation's waters.

12. [Information Concerning 2012 Clean Water Act Sections 303\(d\), 305\(b\), and 314 Integrated Reporting and Listing Decisions](#)
13. [Water Quality Assessment and Total Maximum Daily Loads Information](#)
14. [Geospatial Data Downloads](#)

A. Information update on using and reporting Statewide Statistical Survey Data in ATTAINS, and the National Water Quality Inventory Report to Congress

In the 2010 IR Memo,¹⁵ EPA discussed how States can use CWA Section 106 grant funds to improve monitoring programs and to implement statistically-valid surveys. EPA continues to support both Statewide statistical surveys and site-specific targeted monitoring to cost-effectively meet the reporting requirements under CWA Sections 303(d) and 305(b). EPA's discussion in the 2010 IR memo remains unchanged.

For the 2014 reporting cycle, EPA will again seek to incorporate Statewide statistical survey findings reported in ATTAINS into its national water quality summary. To assist States with reporting Statewide statistical survey data results to EPA, a new web entry tool is available. This tool replaces all Statewide statistical survey data submission tools used in prior cycles, including the Excel spreadsheet template provided for the 2010 and 2012 reporting cycles, and the probability survey module in the Assessment Database (ADB). For the 2014 reporting cycle, the Statewide statistical survey web data entry tool is the only mechanism for reporting Statewide statistical survey results to EPA. States may request access to the Statewide statistical survey web data entry tool available at: [EPA Web Application Access](#).

B. Information on the data systems EPA will support for tracking assessment decisions for inclusion in ATTAINS

As discussed in the 2012 IR Memo,¹⁶ EPA reports on the status of the nation's waters, shares this information with the public and other interested parties, and prepares a biennial National Water Quality Inventory Report to Congress. Data management of water quality assessment decisions is key to analyzing and sharing data across water programs and measuring progress in EPA's Strategic Plan.

In addition to the timely submission of IR data, States should also ensure consistency between their IR report and the associated electronic data submitted to EPA. States and EPA Regions should work together during the review of the IR and ensure that corrections to the report are also made to the associated electronic data. EPA expects that the States' associated electronic data, including geospatial data, should be submitted immediately following EPA's final action on States' Section 303(d) lists.

EPA recognizes that States need flexibility in the tools they use to collect and report IR data. As such, for the 2014 reporting cycle, EPA will continue to support the existing tools for reporting site-specific targeted monitoring data: EPA Assessment Database (ADB), State compatible assessment database, and the Exchange Network (EN) Office of Water Integrated Reporting (OWIR) data flow. As mentioned in the previous section, States that conduct Statewide statistical surveys should report this information in their IR report and use the Statewide statistical survey web data entry tool to submit the associated electronic data. For information on these tools, please visit the following Web sites:

- Site-specific targeted monitoring results
 - [EPA Assessment Database](#)
 - [ADB Compatible Database](#)
 - [EN OWIR data flow \(IR attribute data\)](#) [REDACTED]
- Statistical survey results
 - [Statewide statistical survey web data entry tool](#)

As part of EPA's effort to streamline 303(d) and 305(b) reporting (described in Section 1), EPA is considering revisions to the processes that EPA and States use to manage and report 303(d) and 305(b) data, including the ATAINs data system and the ADB.¹⁷ Working with State partners, EPA expects to make significant progress on these efforts in 2013 and 2014. The first effort has been completing the Integrated Reporting Georeferencing Pilot, which was first discussed in the 2012 IR Memo.

For geospatial data, EPA recommends that States use the Hydrography Event Management (HEM) Tool and HEM EPA Add-On Tools, based in ArcGIS 9.x or ArcGIS 10, to manage assessed and impaired water events. For the 2014 reporting cycle, EPA will continue to support geodatabase or shapefile geospatial data formats, or files sent via the EN utilizing the NHDEvent data flow. For States that are interested in using the EN for submitting their geospatial data and are also using the HEM Tool to manage their geospatial events locally, there is a tool called "HEM to NHDEvent XML Conversion Tool" (HEM2XML) that converts geospatial events into the EN NHDEvent format. For more information on these tools and associated documentation, please visit the following Web sites:

- [HEM Tool](#) [REDACTED]
- [HEM EPA Add-on Tools](#) [REDACTED]
- [EN NHDEvent dataflow \(IR geospatial data\)](#) [REDACTED]
- [HEM2XML tool](#)

15. [Memorandum: Information Concerning 2010 Clean Water Act Sections 303\(d\), 305\(b\), and 314 Integrated Reporting and Listing Decisions](#)

16. [Information Concerning 2012 Clean Water Act Sections 303\(d\), 305\(b\), and 314 Integrated Reporting and Listing Decisions](#)

17. In the interim, for States upgrading their computers to the Windows 7 operating system, please see the [installation instructions](#)

5. Antidegradation and Listing Guidance

Antidegradation is a component of a State's water quality standards (i.e., designated uses, criteria to meet those uses, and antidegradation requirements) that focuses on maintaining and protecting the chemical, physical, and biological integrity of the nation's waters, consistent with the CWA and its implementing regulations. CWA Section 303(d) and EPA's implementing regulations require States to identify waters not meeting any applicable water quality standard (CWA §303(d)(1)(A), 40 C.F.R. 130.7(b)(3)). EPA's listing regulations specify that "applicable water quality standards" refer to criteria, designated uses, and antidegradation requirements (40 CFR 130.7(b)(3)).

Most State water quality assessments have focused on whether numeric and narrative water quality criteria are being attained, and typically, these assessments capture where waters are most in need of restoration. However, it is possible that some waters are not meeting the antidegradation portion of water quality standards. For example, it is possible that available data and information for a water identified by a State as an Outstanding National Resource Water (ONRW) indicates degradation in water quality. If those data and information indicate that the water is not meeting the State's requirement for maintenance and protection of the water quality of the ONRW under the antidegradation portion of its water quality standards, in accordance with CWA and EPA regulations, the waters would be listed on the State's Section 303(d) list even if pollutant concentrations do not exceed water quality criteria levels.

EPA is working to develop additional guidance to address how antidegradation requirements should be considered when assessing waters under CWA Section 303(d).

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, D.C. 20460

OFFICE OF WATER

August 13, 2015

MEMORANDUM

SUBJECT: Information Concerning 2016 Clean Water Act Sections 303(d), 305(b), and 314 Integrated Reporting and Listing Decisions

FROM: Benita Best-Wong, Director /s/
Office of Wetlands, Oceans, and Watersheds

TO: Water Division Directors, Regions 1 – 10
Robert Maxfield, Director, Office of Environmental Measurement and Evaluation, Region 1

I am pleased to provide you with information to assist you and your States as you prepare and review the 2016 Integrated Reports (IR), in accordance with Clean Water Act (CWA) Sections 303(d), 305(b), and 314. This memorandum focuses on the following topics: 1) implementing the CWA 303(d) Program Vision; 2) identifying nutrient-impaired waters based on narrative nutrient water quality criteria and direct evidence of failure to support designated uses; 3) implementing the Water Quality Framework, including the Assessment and Total Maximum Daily Load (TMDL) Tracking and Implementation System (ATTAINS) redesign and reporting of statewide statistical survey data; 4) providing information about the update to the data in the variable portion of the Fiscal Year 2017 Clean Water Act Section 106 grant allocation formula; and 5) clarifying how to assess and assign waters impaired by “pollution” not caused by a “pollutant” to Category 4C.

This memorandum is not regulation and does not impose legally binding requirements on EPA or the States. EPA recommends that the States prepare their 2016 IRs consistent with previous IR guidance including EPA’s 2006 IR Guidance, which is supplemented by EPA’s 2008, 2010, 2012, and 2014 IR memos and this memorandum available at:
<http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/guidance.cfm>.

I would like to thank the Regions and our State partners for their input on the information in this enclosure. I particularly appreciate the continued hard work and dedication in developing the IRs so that we can report to the public on the status of the nation’s waters. If you have any questions or comments concerning this memorandum, please contact me or have your staff contact Shera Reems at 202-566-1264 or reems.shera@epa.gov.

Enclosure

cc: Julia Anastasio, Association of Clean Water Administrators

INFORMATION CONCERNING 2016 CLEAN WATER ACT SECTIONS 303(d), 305(b), AND 314 INTEGRATED REPORTING AND LISTING DECISIONS

1. Implementing the Clean Water Act 303(d) Program Vision

In December 2013, EPA announced a new collaborative framework for implementing the CWA Section 303(d) Program—*A Long-Term Vision for Assessment, Restoration, and Protection under the Clean Water Act Section 303(d) Program* (Vision).¹ This framework is the result of a collaborative process between State and EPA program managers begun in August 2011, which is now articulated in the Vision and supported by the Association of Clean Water Administrators. The Vision provides expectations for both States and EPA to advance the program.

The Vision, as supplemented by this document, is not a rule or regulation. It does not impose any binding legal requirements on EPA, the States, or other stakeholders, and it does not alter CWA 303(d) regulatory obligations to identify impaired or threatened waters and to develop TMDLs for such waters. Under the Vision, States are expected to develop tailored strategies to implement their CWA 303(d) Program responsibilities in the context of their overall water quality goals and individual State priorities.

Recognizing each State is unique, EPA understands States will vary in how they implement the goals of the Vision, depending on the water quality goals of each State. To support State and EPA discussions on re-orienting CWA 303(d) Program responsibilities consistent with the Vision, EPA is providing additional information for States to consider when implementing the Prioritization, Engagement, and Alternatives Goals of the Vision. EPA and States jointly identified these topics as warranting further clarification to promote timely implementation of the Vision and submittal and review of States' 2016 Integrated Reports. EPA will work closely with the States on these issues as States move forward with developing their Integrated Reports.

Prioritization Goal

Long-term Prioritization from 2016 to 2022

Consistent with the Vision, EPA expects each State to identify by 2016 its long-term CWA 303(d) Program priorities through Fiscal Year (FY) 2022 in the context of the State's broader overall water quality goals. The Vision contemplates that this long-term prioritization process will be focused on identifying watersheds or individual waters for priority restoration and protection activities, taking into consideration how CWA 303(d)-related activities could collectively help achieve a State's broader overall water quality goals. The State CWA 303(d) prioritization provides a framework to focus the location and timing of the development of TMDLs, and alternative restoration and protection plans, in relation to other planning and implementation activities that may already exist in the priority watersheds or waters. As such, the State prioritization is a foundation to guide how the State implements CWA 303(d) Program

¹ http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/upload/vision_303d_program_dec_2013.pdf. See also <http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/upload/memo.pdf>, and "Question and Answers" at http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/upload/acwa_qa.pdf.

responsibilities and requirements, which remain unchanged. States have flexibility in how they define their priorities and may use a variety of ways to describe these priorities, which include:

- by geographic units: assessment units, watersheds, ecoregions, or basins;
- by pollutants; or,
- by designated uses.

Regardless of the way a State defines its priorities, the priorities should be articulated in a manner that allows them to be linked to specific assessment units.

Setting long-term CWA 303(d) priorities from FY 2016 to FY 2022 provides States an opportunity to strategically focus their efforts and demonstrate progress over time in achieving environmental results. As such, the long-term priorities are not expected to substantially change from FY 2016 to FY 2022. However, EPA recognizes that some adjustments may be needed due to unforeseen circumstances or planning processes.² In addition, although the new Vision calls for States to identify their priorities through FY 2022, some States may choose to establish a framework that allows them to identify priorities beyond FY 2022.

Additionally, CWA 303(d) prioritization affords the State an opportunity to integrate CWA 303(d) Program priorities with other water quality programs to achieve overall water quality goals. These include State water quality standards (WQS), monitoring, CWA 319, National Pollutant Discharge Elimination System (NPDES), source water protection, and conservation programs. Having CWA 303(d) Program priorities informed by data and information from other relevant programs will help achieve and demonstrate environmental results over time. For example, integration with water quality monitoring programs can lay the groundwork for gathering the needed data to assess baseline conditions in priority waters, to develop TMDLs or other restoration and protection plans, or to determine progress in restoring or protecting priority waters. Integration with other programs can also inform the selection of the approaches that afford the best opportunity to restore or protect water quality, as well as to facilitate the implementation of the pollutant reduction or protection goals of the selected approaches.

The Appendix provides some factors States are encouraged to consider when setting long-term priorities under the CWA 303(d) Program. Recognizing that there is flexibility in how CWA 303(d) Program responsibilities are implemented consistent with existing statutory and regulatory authorities, EPA will work closely with States as they identify long-term priorities that reflect a meaningful plan or roadmap on how best to meet their on-going CWA 303(d) Program requirements.

Consistent with the new Vision, the Integrated Report submitted by States for the 2016 Integrated Reporting cycle should include, or reference, the rationale used to set long-term priorities. The rationale should explain how the State arrived at the long-term priorities; and, to

² As part of reporting progress in implementing the CWA 303d Program Vision, EPA and States developed new performance measures WQ-27 and WQ-28. See WQ-27 and WQ-28 (available at http://water.epa.gov/resource_performance/planning/FY-2015-National-Water-Program-Guidance.cfm). The associated computational guidance documents for these measures will reflect how to incorporate changes in State priorities between 2016 and 2022.

the extent feasible, it should discuss where the State plans to develop future TMDLs, alternative restoration approaches, or protection plans, as well as the extent to which they already exist in priority watersheds or waters. States with priorities extending beyond FY 2022 are encouraged to also include, or reference, such information.

Although State's long-term priorities should be included, or referenced, in the 2016 Integrated Report, EPA's formal decision on the State's CWA 303(d) list will not include action on the State's long-term priorities identified under the Vision.

Importance of Engaging the Public in the State's Long-term Prioritization Process

Consistent with the Vision's Engagement Goal, States are expected to engage their general public and stakeholders in the establishment of CWA 303(d)-related priorities. EPA also expects States to articulate how input from the public was considered and addressed as part of their rationale supporting the prioritization.

EPA recognizes that States have used, and will continue to use, different methods to engage the public. For example, depending on the timing of a State's process for developing its 2016 Integrated Report, some States may choose to use the Integrated Report public notice process as a means to engage the public on establishing CWA 303(d) priorities. Other States may choose to engage the public on their CWA 303(d) priorities through a process separate from the Integrated Report. Whichever process is used, States should be prepared to report on EPA's CWA 303(d) program measure in FY 2016 and to include or reference CWA 303(d) priorities and associated rationale in the 2016 Integrated Report due on April 1, 2016.

Distinction between the Vision Long-term Priorities and the Required Priority Ranking of Listed Waters

In addition to including the long-term priorities from FY 2016 to FY 2022 and the associated prioritization rationale (or references to such priorities and associated rationale), a State's 2016 Integrated Report must include a priority ranking for all listed waters still requiring TMDLs (i.e., all waterbody/pollutant combinations on the CWA 303(d) list), taking into account the severity of the pollution and the uses to be made of such waters and including the identification of waters targeted for TMDL development within the next two years of the CWA 303(d) list (as required by 40 CFR §130.7(b)(4)).

As illustrated below, EPA expects that the required priority ranking and two-year TMDL development schedule will be related to the Vision long-term priorities from FY 2016 to FY 2022. For example, CWA 303(d) listed waters assigned a high priority ranking for TMDL development would likely be included in the Vision long-term priorities. Where States intend to pursue alternative restoration approaches for some CWA 303(d) listed waters, those waters may be assigned a lower priority ranking for TMDL development in the near-term.

Long-term Priorities Consistent with the Vision

- Will not likely include all listed waters
- Includes high priorities for TMDL development; and may also include alternative restoration and protection approaches
- Would likely be a subset of the required priority ranking for TMDL development, if State priorities only focus on TMDL development
- Not required, but the basis for a program measure

Required Priority Ranking in CWA 303(d)

- Ranking of all listed waters (e.g., high, medium, low priorities; development schedule) taking into account the severity of the pollution and use
- Only focuses on ranking of waters for TMDL development, including a two-year TMDL development schedule
- Waters ranked high for TMDL development are likely to be part of Vision priorities
- Some waters ranked low for TMDL development may still be part of the Vision priorities for alternative restoration approaches
- Required by regulation biennially 40 CFR 130.7(b)(4)

Role of Alternative Restoration Approaches

As emphasized in the Alternatives goal of the Vision, the statutory and regulatory obligations to develop TMDLs for waters identified on States' CWA 303(d) lists remain unchanged, and TMDLs will remain the most dominant analytic and informational tool for addressing such waters. However, EPA recognizes that under certain circumstances there are alternative restoration approaches that may be more immediately beneficial or practicable in achieving WQS than pursuing the TMDL approach in the near-term. An alternative restoration approach is a near-term plan, or description of actions, with a schedule and milestones, that is more immediately beneficial or practicable to achieving WQS.

With the exception of impaired waters assigned to Category 4b³ and Category 4c,⁴ impaired waters for which a State pursues an alternative restoration approach to achieve WQS shall remain on the CWA 303(d) list (i.e., Category 5) and still require TMDLs until WQS are attained. Taking into account the severity of the pollution and the uses of waters on the CWA 303(d) list, such waters might be assigned lower priority for TMDL development as alternatives expected to achieve WQS are pursued in the near-term.

Recognizing the statutory and regulatory obligations to develop TMDLs for waters on the CWA 303(d) list, States should consider how long waters have been on the CWA 303(d) list before pursuing alternative restoration approaches. In addition, States should periodically evaluate alternative restoration approaches to determine if such approaches are still expected to be more immediately beneficial or practicable in achieving WQS than pursuing a TMDL approach in the near-term.⁵ If not, States should re-evaluate whether a higher priority for TMDL development should be assigned.

Description of an alternative restoration approach pursued for CWA 303(d) listed waters

EPA and States will work together to determine which is the most effective tool to achieve WQS—be it TMDL development or pursuing an alternative restoration approach in the near-term—for waters that remain on the CWA 303(d) list. To assist States in determining whether an alternative restoration approach is appropriate for a particular water, EPA recommends that States consider the following circumstances associated with the listed water:

- 1) There are unique local circumstances (e.g., the type of pollutant or source or the nature of the receiving waterbody; presence of watershed groups or other parties interested in implementing the alternative restoration approach; available funding opportunities for the alternative restoration approach).
- 2) Initial review of the pollutant or cause of impairment shows that particular point or non-point sources are responsible for the impairment with clear mechanisms to address all sources (both point and nonpoint), as appropriate (e.g., CWA 319 nine-element watershed-based plans or other restoration plans; source water protection plans; setting new limits when permit is re-issued, which alone or in combination with other actions, is expected to achieve WQS in the listed water).

³ For more information on Category 4b, see “Information Concerning 2008 Clean Water Act Sections 303(d), 305(b), and 314 Integrated Reporting and Listing Decisions,” available at http://www.epa.gov/owow/tmdl/2008_ir_memoirandum.html.

⁴ For more information on appropriate placement of waters impaired by pollution under Category 4c, see “Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act,” available at <http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/upload/2006irg-report.pdf>. For waters placed in category 4c, an appropriate plan to address the pollution impairment is needed for such waters to be counted under program measure WQ-27. See also Section 5 of this document, “Clarification on the assessment and assignment of waters to Category 4C.”

⁵ As part of reporting progress under the CWA 303d Program performance measures WQ-27 and WQ-28, for EPA to continue reporting an alternative restoration approach under the measures, a State should demonstrate by 2022 that such an approach is on track to being more immediately beneficial or practicable in achieving WQS than pursuing a TMDL approach in the near-term, by showing steady and continuing improvements in water quality or adequate progress in implementing the plan.

- 3) There is stakeholder and public support for the alternative restoration approach, which is important for achieving timely progress in implementing the alternative.

Once a State decides to pursue an alternative restoration approach for impaired waters, EPA requests that the State provide, or reference, in its Integrated Report a description⁶ of the approach. Such description will provide transparency to the public and help facilitate State and EPA discussions on whether EPA will include the alternative restoration approach under the CWA 303(d) performance measures.⁷ States should consider the following elements in preparing their descriptions:

- Identification of specific impaired water segments or waters addressed by the alternative restoration approach, and identification of all sources contributing to the impairment.
- Analysis to support why the State believes that the implementation of the alternative restoration approach is expected to achieve WQS.
- An Action Plan or Implementation Plan to document: a) the actions to address all sources—both point and nonpoint sources, as appropriate—necessary to achieve WQS (this may include e.g., commitments to adjust permit limits when permits are re-issued or a list of nonpoint source conservation practices or BMPs to be implemented, as part of the alternative restoration approach); and, b) a schedule of actions designed to meet WQS with clear milestones and dates, which includes interim milestones and target dates with clear deliverables.⁸
- Identification of available funding opportunities to implement the alternative restoration plan.
- Identification of all parties committed, and/or additional parties needed, to take actions that are expected to meet WQS.
- An estimate or projection of the time when WQS will be met.⁹
- Plans for effectiveness monitoring to: demonstrate progress made toward achieving WQS following implementation; identify needed improvement for adaptive management as the project progresses; and evaluate the success of actions and outcome.
- Commitment to periodically evaluate the alternative restoration approach to determine if it is on track to be more immediately beneficial or practicable in achieving WQS than pursuing the TMDL approach in the near-term, and if the impaired water should be assigned a higher priority for TMDL development.

⁶ A separate description of the alternative restoration approach for purposes of the CWA 303(d) program may not be needed, if there is existing documentation along with any supplemental information, to show 1) how the alternative approach is expected to meet water quality standards, 2) how it is more immediately beneficial or practicable in achieving WQS, than pursuing a TMDL approach in the near-term, and 3) to which waters the alternative restoration approach applies.

⁷ See WQ-27 and WQ-28 available at http://water.epa.gov/resource_performance/planning/FY-2015-National-Water-Program-Guidance.cfm

⁸ As part of the adaptive management approach to addressing the impairment, EPA expects specific dates may be modified during implementation. The schedule will demonstrate how the planned actions will reduce the loadings from sources to achieve water quality standards. For instance, if BMPs are known, please include them in the description of the alternative restoration approach.

⁹ The estimate or projection may be modified due to new information or experience learned from initial actions.

The State's description of its alternative restoration approach is likely to be case-specific. The degree to which the above elements are addressed in the description is likely to depend on State consideration of numerous circumstances, which include:

- a) severity of the pollution;
- b) uses of the impaired water;
- c) nature of the receiving waterbody;
- d) type of pollutants causing the impairment;
- e) relative mix of nonpoint and point source loadings; and/or
- f) nature of the sources of those loadings.

The description of the alternative restoration approach and the waters to which it applies should be included during public review of the draft CWA 303(d) list or Integrated Report,¹⁰ so that the public has an opportunity to view the State's alternative restoration approaches and the assigned priority ranking for TMDL development for such waters. Additionally, because the Integrated Report and its public comment process occur every two years, States are expected to engage the public on the use of specific alternative restoration approaches and their descriptions as they are developed.

Creation of a subcategory in Category 5 (i.e., 5-alternative) to report on alternative restoration approaches for CWA 303(d) listed waters

Impaired waters on the CWA 303(d) list for which a State develops and pursues an alternative restoration approach shall remain on the CWA 303(d) list (i.e., Category 5) and still require TMDLs until WQS are achieved. EPA has created an optional subcategory under Category 5—subcategory 5-alternative—as an organizing tool to clearly articulate which listed waters have such alternative approaches, and to provide transparency to the public. In addition, this subcategory will facilitate tracking alternative restoration approaches in these CWA 303(d) listed waters.

Because waters for which alternative restoration approaches are pursued still remain on the CWA 303(d) list, EPA will not take action to approve or disapprove a State's alternative restoration approach under CWA 303(d). Therefore, as long as such waters with alternative restoration plans remain on the CWA 303(d) list, EPA's review of the list would not be affected or delayed by whether development of a TMDL or an alternative restoration plan is pursued.

EPA will take into account a State's description of its alternative restoration approach to determine whether it is appropriate for such waters to be in subcategory 5-alternative and whether to include such approaches under the CWA 303(d) performance measures. EPA does not expect that all of the activities or controls to carry out an alternative restoration approach must be fully implemented, or that WQS must have been achieved, before the alternative restoration approach can be reported as a plan under the CWA 303(d) performance measures. However, the alternative restoration approach does need to clearly demonstrate how WQS will be achieved for EPA to include it under the CWA 303(d) performance measures.

¹⁰ When a State develops an alternative restoration approach for a water identified as impaired after a 303(d) list has been approved, the State would place this water on the next Integrated Reporting cycle 303(d) list.

Distinction between Subcategory 5-alternative and Category 4b

Subcategory 5-alternative

- 1) This includes impaired waters on the CWA 303(d) list (i.e., Category 5) for which a State has developed an alternative restoration approach to meet WQS.
- 2) These impaired waters shall remain on the CWA 303(d) list until WQS are achieved or a TMDL is developed. (See Figure 1.) Taking into account the severity of the pollution and uses, such waters might be assigned lower priority for TMDL development as alternative restoration approaches expected to meet WQS are pursued in the near-term.
- 3) For these impaired waters, the State has decided not to pursue a Category 4b demonstration that “other pollution control requirements” required are stringent enough to implement any water quality standard consistent with 40 CFR 130.7(b)(1)(iii).
- 4) As long as such waters remain on the CWA 303(d) list, EPA’s review of the list would not be affected or delayed by whether a TMDL or an alternative restoration approach is pursued.
- 5) EPA will consider the adequacy of the State’s description of the alternative restoration approach in determining whether to include such an approach under the CWA 303(d) performance measures.

Category 4b

- 1) As noted in the “Information Concerning 2008 Clean Water Act Sections 303(d), 305(b), and 314 Integrated Reporting and Listing Decisions,”¹¹ Category 4b includes impaired waters for which a State has provided sufficient demonstration that there are other pollution control requirements sufficiently stringent to achieve applicable WQS within a reasonable period of time.
- 2) These impaired waters are not included in the State’s CWA 303(d) list consistent with 130.7(b)(1)(iii) (Category 5). (See Figure 1.)
- 3) EPA reviews and approves the exclusion of such waters from Category 5 consistent with CWA requirements.

¹¹ For more information on Category 4b, see “Information Concerning 2008 Clean Water Act Sections 303(d), 305(b), and 314 Integrated Reporting and Listing Decisions,” available at http://www.epa.gov/owow/tmdl/2008_ir_memorandum.html.

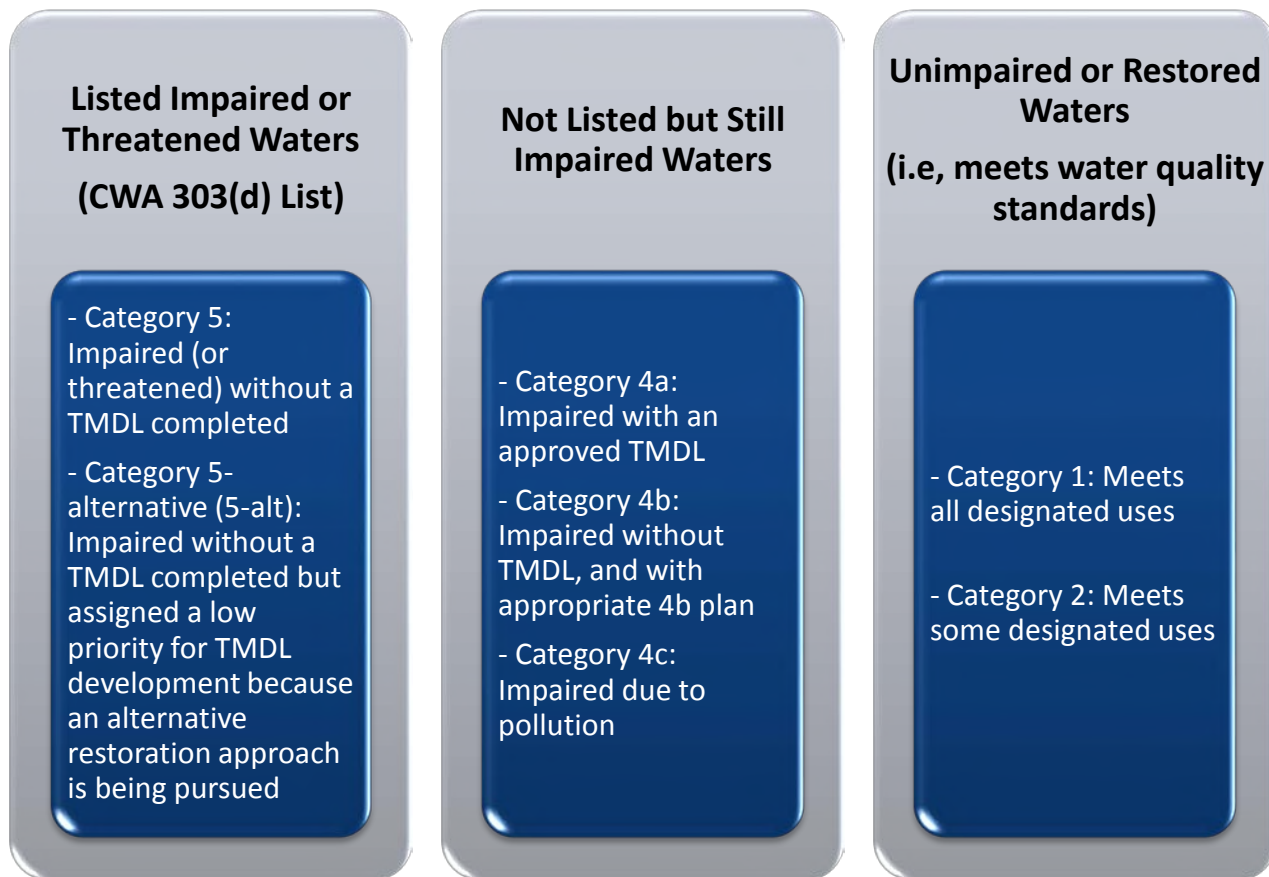


Figure 1: Categories of impaired waters when: 1) a TMDL is still needed; 2) a TMDL or Category 4b demonstration has been developed, or the impairment is due to pollution and not a pollutant; or, 3) it is now attaining WQS for assessed designated uses.

2. Continue identifying waters impacted by nutrients for the Section 303(d) list for States without numeric nutrient water quality criteria

Addressing nutrient pollution in our nation's waters continues to be one of EPA's top priorities, and identifying nutrient-impaired waters is an important step in a State's process to prioritize and accelerate nutrient reduction efforts. The CWA and EPA's implementing regulations require States to identify water-quality limited segments still requiring TMDLs where pollution controls are not stringent enough to meet any applicable water quality standard. Applicable WQS include designated use, water quality criteria (numeric and narrative), and antidegradation requirements.

To assist States with identifying nutrient-impaired waters, in the 2014 Integrated Reporting Memorandum (IR Memo),¹² EPA provided examples of approaches that can be used for assessing whether waters are attaining nutrient-related narrative criteria and/or supporting designated uses. Collectively, the examples address a number of different designated uses, are based on causal and nutrient response parameters, and rely on various types of assessment information such as the evaluation of water column data against nutrient targets, visual

¹² *Information Concerning 2014 Clean Water Act Sections 303(d), 305(b) and 314 Integrated Reporting and Listing Decisions* available at <http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/2014-memo.cfm>.

observations, field surveys, stressor identification analysis, biological information, and public feedback and comments. The 2014 IR Memo also provided recommendations to facilitate stakeholder input and EPA review of States' CWA 303(d) lists, such as States describing in their assessment methods applicable data quantity, quality, and representativeness expectations for making water quality attainment determinations.

EPA continues to expect States to evaluate the status of their waters with respect to nutrient-related impairments and to add to their CWA 303(d) list waters failing to meet any applicable water quality standard. For those States that have developed nutrient-related assessment methodologies, EPA encourages States to continually refine their nutrient-related assessment methodologies and to share them with neighboring States to collaboratively bolster nutrient assessment programs, as needed. For States without nutrient-related assessment methodologies, there is still a requirement to assemble and evaluate all existing and readily available water quality-related data and information against all applicable numeric and narrative WQS to develop the CWA 303(d) list.

3. Implementation of the Water Quality Framework: Assessment and Total Maximum Daily Load (TMDL) Tracking and Implementation System (ATTAINS)

A. Water Quality Framework

In 2014, EPA introduced the Water Quality Framework, which is a new way of integrating EPA's data and information systems (e.g., STORET/WQX, ATTAINS, NHD*Plus*, GRTS)¹³ to streamline water quality assessment and reporting while providing a more complete picture of the nation's water quality. Benefits of this approach include:

- Reduces State burden by streamlining the CWA assessment and reporting process;
- Provides the means to link monitoring data to assessment decisions and action plans to restoration success;
- Links the broader water quality context provided by national and statewide statistical surveys to the localized assessment decisions;
- Provides better measurement and reporting of water quality improvements;
- Provides more transparency in reporting water quality actions and supporting water quality decision making;
- Allows for tools that can be used to identify relevant monitoring data for water quality assessments;
- Supports State development of tools to automate the screening of monitoring data against WQS; and
- Connects data, decisions, and actions geospatially.

¹³ STORage and RETrieval Data Warehouse (STORET)/Water Quality Exchange (WQX); Assessment TMDL Tracking and Implementation System (ATTAINS); National Hydrography Dataset *Plus* (NHD*Plus*), Grants Reporting and Tracking System (GRTS)

B. Water Quality Framework: ATTAINS Redesign

As discussed in the 2012 IR Memo,¹⁴ IR data include State water quality assessment decisions, attribute data, and the geospatial data representing the geographic locations of those assessed waters. This information is needed in order for the public to better understand the status of the nation's waters. EPA's ATTAINS database¹⁵ is the repository for State IR attribute data, and the Reach Address Database¹⁶ contains State IR geospatial data. EPA compiles State-submitted IR data to develop and publish the National Water Quality Inventory Report to Congress (CWA Section 305(b) Report), determine States' variable portion of the Section 106 grant allocation formula, inform water quality decisions, and to conduct and support analyses to help restore the nation's waters.

In 2013, EPA worked with States to complete a retrospective review of the IR process and identified several opportunities to reduce workload and to improve the timeliness of State submittals of Integrated Reports, and the timeliness of EPA review of the Integrated Report. Although the 2002 IR guidance encouraged electronic reporting, many States and Regions continue to use paper reports as the official record creating discrepancies between the paper version and the corresponding electronic data. In 2014, work on the Water Quality Framework identified a number of improvements to the IR process, with a specific focus on moving from paper to electronic processes. This effort will enable the ATTAINS system to be a more valuable tool throughout the IR process, reducing time and costs for States and EPA through the use of automated processes, electronic reporting and review capabilities, and validation checks.

The ATTAINS updates will occur in two Phases:

- **Phase 1:** For the 2016 IR cycle, all States will use the existing systems¹⁷ for tracking assessment decisions and submitting the official electronic IR submission. Some States may also pilot the new system using their 2016 IR information to identify improvements for the 2018 IR cycle.
- **Phase 2:** The 2018 IR cycle¹⁸ will serve as the transition to the new ATTAINS for all States. EPA encourages States to utilize resources available under the Exchange Network to make this transition.¹⁹ The data systems outlined in the 2014 IR Memo will no longer be supported beginning in the summer of 2017.

¹⁴ *Information Concerning 2012 Clean Water Act Sections 303(d), 305(b) and 314 Integrated Reporting and Listing Decisions* available at http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/ir_memo_2012.cfm

¹⁵ Assessment and Total Maximum Daily Load (TMDL) Tracking and Implementation System (ATTAINS) available at <http://www.epa.gov/waters/ir>

¹⁶ Geospatial Data Downloads available at <http://www.epa.gov/waters/data/downloads.html>

¹⁷ During the 2016 IR cycle, EPA will continue to support the existing data systems outlined in the *Information Concerning 2014 Clean Water Act Sections 303(d), 305(b) and 314 Integrated Reporting and Listing Decisions* available at <http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/2014-memo.cfm>

¹⁸ For the 2018 IR cycle, the new ATTAINS system will replace the existing NTTS and ADB systems, OWIR-ATT data flow that exists within the Exchange Network, as well as incorporate the ATTAINS Web Express system that is used for submitting data to EPA and entering State statistical survey summary information. This new system will provide one interface and data model for all of the integrated reporting and TMDL information.

¹⁹ For additional information about the Exchange Network, visit <http://www.exchangenetwork.net/>

C. Statewide Statistical Survey Data in ATTAINS

EPA continues to support both statewide statistical surveys and site-specific targeted monitoring to meet the reporting requirements under CWA Sections 303(d) and 305(b). Statistical surveys enable States to report on the condition of the broad population of waters using a representative sample, and targeted monitoring supports identification and listing of specific impaired waters. For the 2016 IR cycle, EPA will again incorporate statewide statistical survey findings reported to EPA into the state-level water quality summaries displayed on the ATTAINS website and to use both survey and site-specific results in its national water quality summary. To assist States with reporting statewide statistical survey data results to EPA, the statewide statistical survey web data entry tool is available at: <https://attainsweb.epa.gov>.

4. Use of Water Quality Impairment Data to Update the Variable Portion of the Fiscal Year 2017 Clean Water Act Section 106 Grant Allocation Formula

The CWA Section 106 regulations (40 CFR Part 35.162) set out the allocation formula for grants to States and Interstate Compact Commissions. The CWA requires EPA to allocate funds to States and interstate agencies “on the basis of the extent of the pollution problem in the respective States.” The formula includes a base and six variable components. The variable components of the CWA Section 106 grant allocation formula currently include: surface water area, ground water use, point sources, nonpoint sources, water quality impairment, and population of urban areas. Water quality impairment accounts for 35% of the variable portion.

The data in the CWA Section 106 grant allocation formula will be updated in calendar year 2016 for use in the Fiscal Year 2017 Section 106 grant allocation. The water quality impairment variable component of the CWA Section 106 grant allocation formula will be included in this update. The water quality impairment data include: river and stream miles; lake, pond, and reservoir acres; estuary square miles; ocean shoreline miles; wetland acres; and Great Lakes shoreline miles (40 CFR Part 35.162 Table 1).

To support the formula data update, EPA will use the most current and complete assessment results from States available to the public in ATTAINS.²⁰ EPA will use the data source that represents the most comprehensive designation of impaired waters including Integrated Report categories 4a, 4b, 4c, 5, 5-alt, and 5m; separate 305(b) report categories “not supporting” or “impaired;” or statewide statistical survey result categories included in the State’s definition of “not supporting” or “impaired.” For State water quality impairment data to be used in the CWA Section 106 grant allocation formula, the data needs to be available to the public in ATTAINS by September 1, 2016.

²⁰ EPA recommends that States visit the ATTAINS website at <http://www.epa.gov/waters/ir> to see what data is available. If a State would like more recent data to be included in the variable component of the CWA Section 106 grant allocation formula, contact EPA to discuss the process to submit the data files to EPA. In this instance, EPA will need the State’s data no later than July 1, 2016 in order to allow for EPA contractors to process the data and for the State to review and allow for EPA to release the data to the public. The CWA Section 106 grant allocation formula is not contingent on an approved CWA 303(d) list.

5. Clarification on the assessment and assignment of waters to Category 4C

As the nation's waters face an increasing degree of stress from anthropogenic influences, and the effects of climate change and extreme weather events, it will become important to more fully understand the impacts and causes of all types of pollution on our nation's waters. While the focus of previous IR Guidance has predominantly been on the assessment and listing of impairments caused by pollutants and waters assigned to Category 5 (i.e., a State's CWA 303(d) list of impaired and threatened waters needing a TMDL), the assessment and categorization of impairments caused by pollution²¹ not caused by a pollutant have not been covered as extensively. However, the effects of such pollution can be significant, including the effects of hydrologic alteration²² or habitat alteration. A 2010 study by the U.S. Geological Survey²³ found that anthropogenic hydrologic alteration is extensive in the U.S. and may be a primary cause of ecological impairment in river and stream ecosystems. Examples of such alteration include: water withdrawals, impoundments, or extreme high flows that scour out stream beds, destabilize stream banks and cause a loss of habitat. Climate change is expected to exacerbate these effects. Recognizing the interplay between pollutants and pollution, EPA encourages States to more fully monitor, assess, and report the impacts of all types of pollution, thereby improving the opportunities for increasing resilience and restoration of these waters. To assist States with this effort, EPA is clarifying previous guidance about the assessment and categorization of waters into Category 4C when a State demonstrates that the failure to meet an applicable water quality standard is not caused by a pollutant, but instead is caused by other types of pollution.²⁴

Assessment of waters impaired by pollution not caused by a pollutant

It is important to recognize that a water body segment is considered impaired when the applicable WQS²⁵ are not met or not expected to be met (i.e., threatened). States typically focus assessments on determining whether narrative or numeric water quality criteria are met. When assessing for impacts caused by hydrologic or habitat alteration, States can assess whether the

²¹ Defined under the CWA as “the man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water” (Section 502(19))

²² In discussing causes that contribute to the actual or threatened impairment of a designated use in a waterbody, EPA defines “flow alteration” as “frequent changes in flow or chronic reductions in flow that impact aquatic life” U.S. EPA, *Guidelines for Preparation of the Comprehensive State Water Quality Assessments (305(b) Reports) and Electronic Updates*, EPA Doc. No. 841-B-97-002A, 4-14 (1997). Hydrologic alteration is the current term in the state of the science for flow alteration, which also now includes impacts to aquatic life as well as recreation, drinking water, etc.

²³ Carlisle, Wolock and Meador, “Alteration of stream flow magnitudes and potential ecological consequences: a multiregional assessment,” *Front Ecol Environ* 2010; doi:10.1890/100053.

²⁴ See U.S. EPA, *Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act*, available at http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/2006IRG_index.cfm

²⁵ EPA's 303(d) listing regulations at 40 CFR § 130.7(b)(3) define a “water quality standard applicable to such waters” and “applicable water quality standards” as “those water quality standards established under section 303 of the Act, including numeric criteria, narrative criteria, waterbody uses and antidegradation requirements.” Also see, *Information Concerning 2014 Clean Water Act Sections 303(d), 305(b) and 314 Integrated Reporting and Listing Decisions* available at <http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/2014-memo.cfm>

narrative criteria are met, for example, by using a biological narrative²⁶ or numeric flow criteria.²⁷ However, EPA recognizes that it is possible to have an impaired or threatened designated use that may not be determined through the assessment of available numeric and narrative criteria alone.²⁸ For example, if a perennial stream is dry or has no flow and field staff are not able to collect a sample, then assessment of the designated use based solely on the sample results of an evaluation of narrative or numeric criteria may not be possible. However, data or information based on visual observations of no water in a perennial stream would be information on the physical condition of the stream, and would demonstrate the aquatic life or recreational use is most likely not being attained and a State may conclude that the designated use is impaired. EPA encourages States to evaluate all existing and readily available data and/or *information* when determining the attainment status of a water. Thus, data and/or *information* documenting significant hydrologic or habitat alteration could be used to make a use attainment decision for an impairment due to pollution not caused by a pollutant and should be collected, evaluated, and reported as appropriate.

There are many types of information that could be readily used to identify threatened or impaired waters. This includes basic visual assessments of habitat alteration or flow alteration by field personnel. For instance, some States already report on “flow severity,” an observation on the presence of no flows, low flows, stand-alone pools, or extreme high flows. In addition, States may already have access to, and rely on, other readily available information, such as USGS StreamStats, gage data, remote sensing or dam inventories.²⁹ The use of these data sources to document changes to the flow regime over time could independently indicate designated use impairment by pollution not caused by a pollutant. Other States have sought clarity on how to interpret these types of data and information. For example, there were some cases where remote observations of gage data may have led States to not travel to a site when there were extreme conditions and subsequently no data *or information* were captured to document the stream condition. Where States could not sample, States may have simply recorded “no data” or “more information needed” in site visit records because they could not obtain physical, chemical or biological sampling data. However, EPA recommends that, rather than recording this as “no data,” this information be documented and considered in the assessment determination for that

²⁶ For instance, several States have biological narratives that require an aquatic ecosystem to support and maintain a balanced and indigenous community of organisms, having species composition, diversity, population densities and functional organization similar to that of reference conditions. Such narratives can evaluate whether the hydrology or habitat needed to support those requirements is present.

²⁷ As of 2014, ten States and six tribes with Treatment as a State status have adopted flow criteria.

²⁸ See Wilcher, LaJuana, EPA to Cashell, Lois, FERC. (January 18, 1991), for EPA’s interpretation of protecting water quality beyond only criteria; Also see, *Information Concerning 2014 Clean Water Act Sections 303(d), 305(b) and 314 Integrated Reporting and Listing Decisions* available at

<http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/2014-memo.cfm>

²⁹ See U.S. EPA, *Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act*, available at

http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/2006IRG_index.cfm for a further discussion with additional information types to be considered. Appendix L of the 1997 305(b) Guidelines includes example types of information for source categories specifically for hydromodification, modeling analysis using PHABSIM or other instream flow models to document adverse impacts. U.S. EPA, *Guidelines for Preparation of the Comprehensive State Water Quality Assessments (305(b) Reports) and Electronic Updates*, EPA Doc. No. 841-B-97-002A. (1997).

water body segment. This will allow managers to be more fully informed for setting priorities and developing plans for restoration of these waters.

Categorization of waters impaired by pollution

EPA continues to recommend that States assign all of their surface water segments to one or more of five reporting categories.³⁰ Regarding waters impaired by pollution not caused by pollutants, EPA encourages States to use data and/or information to assign waters consistent with the category descriptions below. If pollution impairment is identified, EPA continues to expect regular monitoring to occur when samples can be collected and continued identification of potential pollutant impairments for listing in Category 5.

Category 3 Assessment units should be reported here when there are not enough data and/or information to determine if WQS are impaired. This category should not be used when data and/or information is available about impairments due to pollution not caused by a pollutant, including for instance, where hydrologic alteration or impacts from habitat alteration impairs a designated use but no narrative or numeric water quality criteria can be assessed; such waters should be placed in Category 4C.

Category 4C If States have data and/or information that a water is impaired due to pollution not caused by a pollutant (e.g., aquatic life use is not supported due to hydrologic alteration or habitat alteration), those causes should be identified and that water should be assigned to Category 4C. Examples of hydrologic alteration include: a perennial water is dry; no longer has flow; has low flow; has stand-alone pools; has extreme high flows; or has other significant alteration of the frequency, magnitude, duration or rate-of-change of natural flows in a water; or a water is characterized by entrenchment, bank destabilization, or channelization. Where circumstances such as unnatural low flow, no flow or stand-alone pools prevent sampling, it may be appropriate to place that water in Category 4C for impairment due to pollution not caused by a pollutant. In order to simplify and clarify the identification of waters impaired by pollution not caused by a pollutant, States may create further sub-categories to distinguish such waters. While TMDLs are not required for waterbody impairments assigned to Category 4C, States can employ a variety of watershed restoration tools and approaches to address the source(s) of the impairment.

Category 5 If States have data and/or information that a water is impaired due to a pollutant, it would need to be reported in Category 5. This is true even if this segment is also in Category 4C for an impairment due to pollution not caused by a pollutant. In that case, the State should list that water in Category 5 and identify the pollutant causing the impairment (e.g., nutrients) and should also indicate the nature of the pollution (e.g., hydrologic alteration) as a cause of impairment under Category 4C. If the water is later delisted for the pollutant (e.g., nutrients), but pollution (e.g., hydrologic alteration) is still impairing the water's use, then the water should remain in Category 4C. Consistent with previous IR Guidance, if a waterbody is impaired or

³⁰ See U.S. EPA, *Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act*, available at http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/2006IRG_index.cfm

threatened, and the State does not have data and/or information on whether a pollutant is causing the impairment, States would need to assign such waters to Category 5.³¹ If assessment of new data and/or information subsequently demonstrates that the impairment is not associated with a pollutant and is due to pollution not caused by a pollutant, the waterbody-pollutant combination would no longer need to be assigned to Category 5 and may be placed into Category 4C.

³¹ Ibid.

Appendix – Considerations for setting State long-term priorities from 2016 to 2022

Consistent with the CWA 303(d) Program Vision, EPA expects each State to establish long-term CWA 303(d) priorities from 2016 to 2022 in the context of its broader, overall water quality goals. The CWA 303(d) Program is able to integrate other programs because it translates State WQS into pollution reduction targets for the point source permitting and nonpoint source management programs as well as other programs outside the CWA. Linking the CWA 303(d) Program priorities with those of other programs aids in strategically focusing limited resources to address priority waters through water quality assessments, TMDL or alternative restoration approaches, water quality protection strategies, implementation actions and/or follow-up monitoring.

EPA encourages States to consider various factors—ranging from public interest, environmental considerations as well as resource implications, in addition to the statutory factors of severity of the pollution and uses of impaired waters—to inform its priority setting consistent with the Vision. These factors include:

- number, extent and age of listing of segments on a State CWA 303(d) list;
- number of waters affected by a particular pollutant or impairment on a State CWA 303(d) list;
- proximity of listed waters to each other within a watershed;
- relative significance of the environmental harm, public health risk, or threat of the impaired waters based on severity of the impairment, results of state-wide statistical surveys, National Aquatic Resource Surveys, vulnerability of the aquatic resource, or other appropriate information;
- specific regional and national priorities;
- degree to which CWA 303(d) Program could be integrated with other programs such as WQS, nonpoint source management, monitoring, NPDES (including programmatic needs for wasteload allocations for permits that are coming up for revisions or for new or expanding discharges) and source water protection programs, to achieve those environmental results;
- particular pollutants, waters or designated uses of primary interest to the public;
- likelihood of success in restoring impaired waters;
- technical and data considerations such as availability of monitoring data or models;
- number and relative complexity of the TMDLs; and,
- number and extent of healthy waters identified for planning and protection.

Each State has flexibility in considering these and other appropriate factors in its prioritization. The consideration of these factors will be state-specific, and are likely to be shaped by what is important to its public and what resources and information are available to the State. As such, the extent to which these and other appropriate factors are addressed in the rationale submitted with the CWA 303(d) priorities in the Integrated Report will be unique to each State. In addition to explaining how the State arrived at the long-term priorities, the rationale for the CWA 303(d) priorities should also articulate the State plans to develop future TMDLs, alternative restoration approaches or protection plans and the extent to which they already exist in priority watersheds or water segments.

Notwithstanding this flexibility, EPA expects that States will identify priorities that reflect a meaningful plan (roadmap) on how best to meet their on-going CWA 303(d) Program requirements to address impaired waters over time. EPA plans to continue to work with States as they develop their CWA 303(d) Program priorities.

Additionally, recognizing there are different approaches to prioritizing waters, EPA offers several tools to assist States on prioritization. For example, EPA's Recovery Potential Screening Tool, available at www.epa.gov/recoverypotential, is useful for comparing restorability of impaired waters across various watersheds. Another tool from EPA is Waterscape, a GIS-based framework for identifying priority watersheds, wherein States choose the parameters and weigh the importance of each, and may compare various alternative prioritization scenarios. Also, the Nitrogen and Phosphorus Pollution Data Access Tool (NPDAT), at www.epa.gov/nutrientpollution/npdat, is a GIS-based tool designed to assist in identifying priority watersheds to address nutrient pollution.

States are presently identifying their priority areas to establish information for purposes of the WQ-27 performance measure (i.e., TMDLs, alternative restoration approaches for impaired waters, or protection approaches for unimpaired waters). States are encouraged to keep changes to their priority areas to a minimum to track progress toward the 2022 target. However, if a State changes its priority areas before 2022, the information for this performance measure would need to be updated to reflect these changes. Before changing their priority areas, States are encouraged to first consider reporting activities outside of priority areas in the WQ-28 performance measure.³²

³² See footnote 2 for more information on the WQ-27 and WQ-28 performance measures.

Vermont Surface Water Assessment and Listing Methodology

In accordance with
USEPA 2006 Guidance

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Executive Summary

The federal Water Pollution Control Act, also known as the Clean Water Act, requires the State of Vermont and each of the other forty-nine states to develop and submit to the US Environmental Protection Agency two surface water quality-related documents. The documents, to be prepared every two years, arise out of two sections of the Act. Section 305b of the Act requires submittal of a report that describes the quality of the State's surface waters and that contains an analysis of the extent to which its waters provide for the protection and propagation of a balanced population of fish, shellfish and wildlife. This analysis is also referred to as the extent to which Vermont's waters achieve the Act's fishable and swimmable goals. The biennial Vermont Water Quality Assessment Report is commonly known as the "305b Report."

The second document, developed in response to Section 303d of the Act, is a listing of surface waters that:

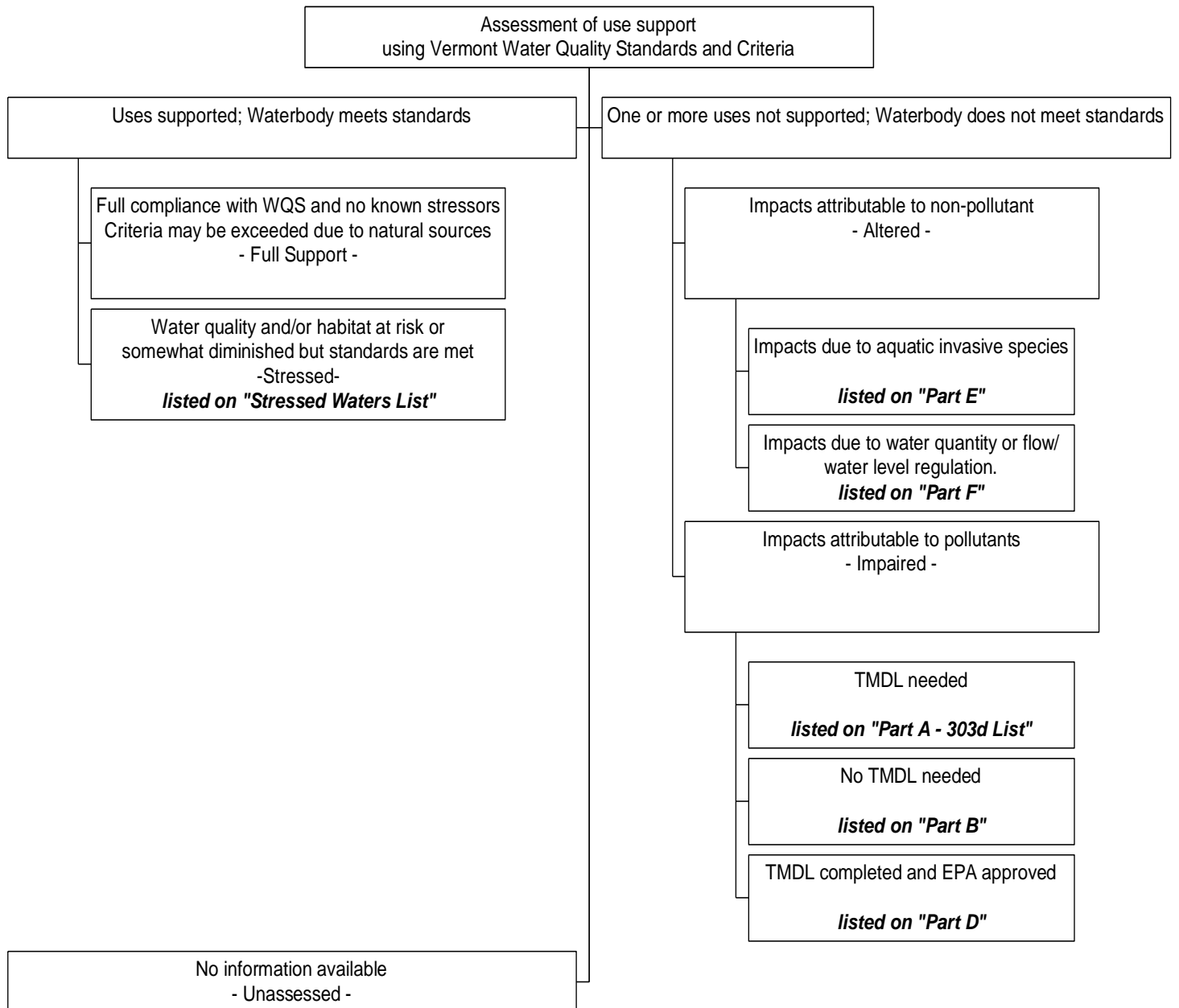
- 1) are impaired or threatened by one or more pollutants; and,
- 2) are not expected to meet Water Quality Standards within a reasonable time even after the application of best available technology standards for point sources of pollution or best management practices for nonpoint sources of pollution; and,
- 3) require development and implementation of a pollutant loading and reduction plan, called a Total Maximum Daily Load, which is designed to achieve Water Quality Standards.

The collection, analysis and evaluation of water quality monitoring data and other information represent the assessment of a water's condition. The assessment of a water is most accurate when judgements about the water's condition are made using chemical, physical and/or biological data of known reliability collected through monitoring. While not as reliable as data collected through monitoring, an assessment of a water's condition can also take into account professional opinion, direct observations or other qualitative information.

The Vermont Water Quality Standards, revised and promulgated by the Vermont Water Resources Board, provide the basis used by the Vermont Department of Environmental Conservation in determining the condition of surface waters including whether the water meets (attains) or does not meet (exceeds or violates) certain criteria. The assessment of a water's condition within the context of the Water Quality Standards requires consideration of the water's classification and management type, a variety of designated or existing uses, and a series of criteria which can be numerical or narrative. The outcome of an assessment conducted by the Department is to categorize Vermont's surface waters as either "full support," "stressed," "altered," or "impaired." Over time, the Department is gradually reducing the number of waters characterized as "unassessed."

This document describes the process used by the Department of Environmental Conservation when making water quality attainment decisions to fulfill 305b reporting and 303d listing requirements. The document contains an overview of the Water Quality Standards (Chapter 1); a description of water quality monitoring approaches that are utilized and their linkage to assessment efforts (Chapter 2); the four assessment categories and the factors and decision principles applied when evaluating data and other information to determine if a water meets the Standards (Chapter 3); and, the rationale when deciding where and how to list a particular water (Chapter 4). Figure 1 illustrates the major components of DEC's assessment and listing process.

Figure 1. Organization of Vermont's Water Quality Assessment and Listing Methodology



Chapter One. Introduction

The Vermont Department of Environmental Conservation (DEC) is charged with implementing the Vermont Water Quality Standards (VTWQS). As part of this responsibility, the Department must characterize the quality of Vermont's surface waters and determine what factors or stressors may be bringing about observed changes. In Vermont and nationwide, significant emphasis is placed on how the condition of surface waters is determined and whether waters are in compliance with the applicable water quality standards. The methods used for making these determinations are important because whether the waters meet or do not meet the water quality standards informs and directs water quality management strategies for each waterbody and may lead to significant regulatory consequences. It is essential that determinations are accurate and defensible.

The Water Quality Standards provide the specific criteria and policies for the management and protection of Vermont's surface waters. The classification of waters (rivers, streams, lakes and ponds) as Class A, Class B or Class B with Waste Management Zone are the management goals to be attained and maintained. The classification also specifies the designated water uses for each class and establish narrative and numeric criteria to support designated and existing uses. The following table serves to indicate applicable designated uses. Chapter Four of this Assessment Methodology describes DEC's approach towards assessing the level of support of these designated uses in light of the criteria established in the Water Quality Standards.

Table 1. Designated Uses for Water Classifications.

Designated Uses	Class A(1) – Ecological Waters	Class A(2) – Public Water Supplies	Class B Waters
Aquatic Biota, Wildlife & Aquatic Habitat	✓	✓	✓
Aesthetics	✓	✓	✓
Swimming & Other Primary Contact Recreation	✓		✓
Boating, Fishing & Other Recreation Uses	✓		✓
Public Water Supplies		✓	✓
Irrigation of Crops & Other Agricultural Uses			✓

Surface water assessment is part science and part careful observation of the causes of the measured conditions. Assessment begins with an examination of the water's chemical, physical and biological condition, and the causality of the conditions observed. Data is used to estimate the water quality standards "attainment status" of waters. Selecting representative data with known and quantifiable precision is the first step in assessing standards attainment. If a waterbody is determined not to attain one or more criteria of the Vermont Water Quality Standards, then it is first necessary to determine whether or not the impact to the surface water is of natural or anthropogenic origin. Identifying the actual cause of impairment will also have considerable bearing on decisions about what approach to initiate to restore the waterbody. The Department also seeks to provide avenues for Vermont's citizenry to contribute in a meaningful way to the protection and improvement of waters.

This document explains how DEC carries out surface water quality monitoring and assessment activities and how it makes decisions on a regular basis regarding a water's condition based on the Vermont Water Quality Standards. It also describes how DEC considers certain factors and how DEC makes decisions when interpreting the meaning of samples and observations obtained through monitoring efforts, whether monitoring information is generated by DEC or by others. This document does not describe DEC's broad array of monitoring programs, which can be found in Appendix A of the [Vermont DEC Water Quality Monitoring Strategy 2011 -2020](#).

Throughout the Assessment and Listing Methodology document, the terms "waters" and "water resources," are used generically and mean lakes and ponds, streams and rivers, and wetlands. The Department does not conduct or carry out any systematic monitoring on many types of waterbodies including wetlands, vernal pools, lakes and ponds less than five acres, closed trout waters, rivers and streams not considered "wadeable," ephemeral or intermittent streams. This Assessment and Listing Methodology document is evolving and reflects the ever-improving methods available for water quality monitoring and interpretation. Vermont's citizenry, federal and academic collaborators, and others are encouraged to view the Assessment and Listing Methodology with an eye towards where and how they can improve or add to the quality of data and other information used to understand, protect, and improve Vermont's water resources.

Chapter Two. Surface Waters Assessment Methodology

Overview and Data Sources

The assessment process involves identifying, compiling and evaluating all existing and readily available water quality data and information as well as evident point and nonpoint source pollution impacts on designated and existing uses specific to the basins and waters being assessed in any given year. The data and other information are maintained in EPA's Assessment Database (ADB) or in databases specifically designed to allow the population of the ADB. Vermont relies on the following sources of reliable data and information when assessing use support:

- 1) DEC Watershed Management Division (monitoring data)
- 2) DEC Wastewater Management Program (National Point Source Discharge Elimination System permit compliance, indirect discharge permit compliance, residuals management)
- 3) DEC Waste Management and Prevention Division (solid and hazardous waste sites monitoring data)
- 4) DEC Laboratory Services at the R.A. LaRosa Laboratory (quality assurance, analytical services, pollutant data)
- 5) Vermont Agency of Natural Resources Enforcement Division (violations of water quality standards)
- 6) Vermont Department of Fish & Wildlife (data on game fish and temperature, habitat studies)
- 7) Vermont Department of Health (beach closure information, fish consumption risk assessments)
- 8) Vermont Department of Forests, Parks, and Recreation (bacteriological testing, beach closure information)
- 9) Vermont Agency of Agriculture, Food and Markets (agricultural water quality violations)
- 10) US Department of Agriculture, Natural Resource Conservation Service (agricultural nonpoint sources, locations of pollution abatement projects)
- 11) Citizens and citizen associations (citizen monitoring data, location of sources, complaints)
- 12) US Geological Survey Water Resources Division (monitoring and research)
- 13) US Forest Service (fish habitat and water quality data and information)
- 14) US Environmental Protection Agency (monitoring and research)
- 15) US Army Corps of Engineers (environmental assessments of project waters)
- 16) University of Vermont, Vermont State Colleges System and other colleges (monitoring and research)

The DEC Biomonitoring and Aquatic Studies and River Management Sections provide much of the data used in the assessment of monitored river miles. The DEC Lakes and Ponds Section provides much of the data used in the assessment of monitored lake acres. The other sources noted above provide fewer and less widespread, but nevertheless important, data points.

Rotational Watershed Assessment Approach

For the purposes of water quality management planning and implementation, which includes assessing and reporting water quality information, Vermont has been divided into fifteen planning basins. Each major basin has from four to twenty-two river watersheds, subwatersheds and river mainstem segments. These sub-watersheds and mainstem segments and the various lakes and ponds are known as "waterbodies." There are a total of 208 river and stream waterbodies (37 as mainstem segments) and 574 lake and pond waterbodies designated throughout Vermont. The fifteen major river basins are located in one of the four large regional drainages: Lake Champlain, Connecticut River, Lake Memphremagog, or Hudson River. The fifteen basins are presented in Figure 2 below.

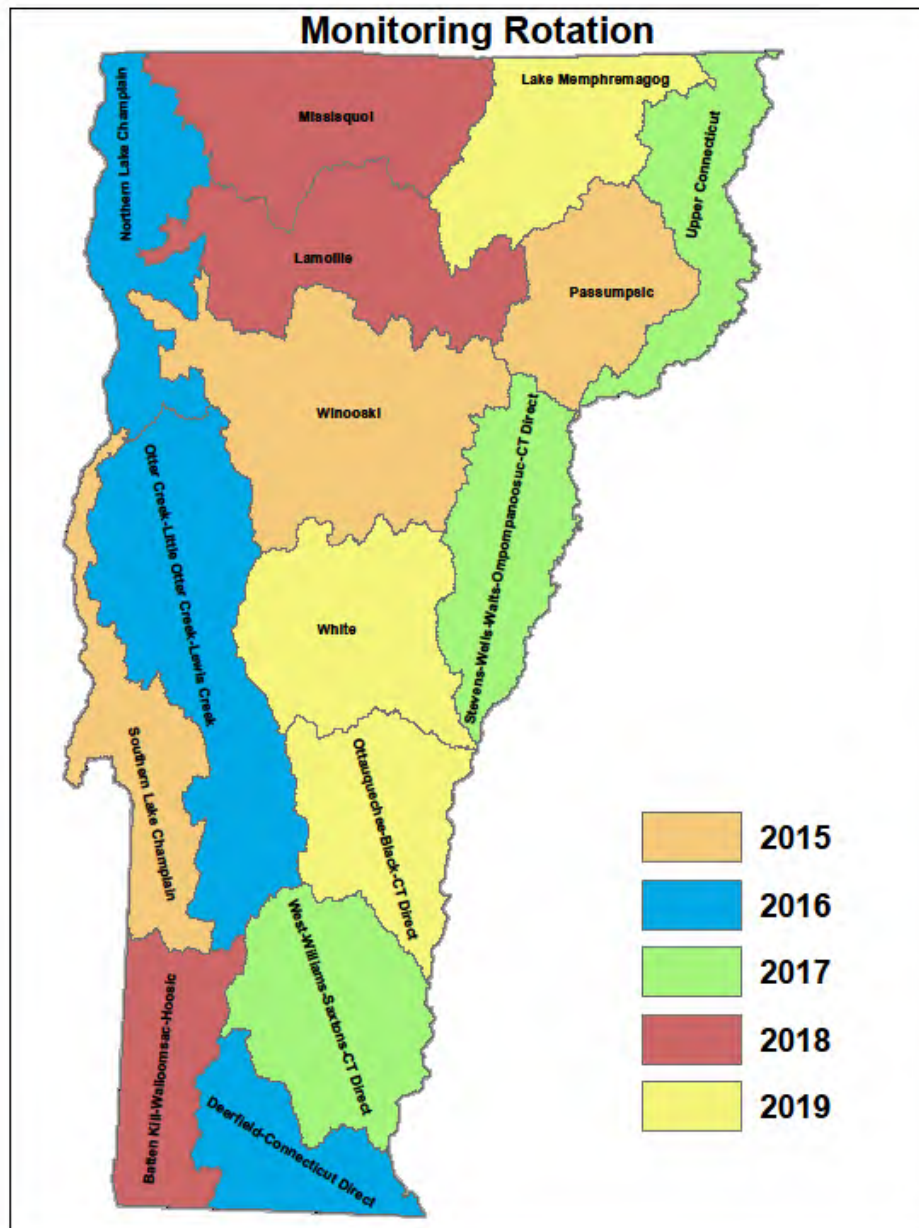


Figure 2. Vermont's 15 major planning basins with rotation monitoring schedule

In order to more thoroughly assess the State's surface waters and to take advantage of all existing and readily available sources of water quality information, the DEC Watershed Management Division (WSMD) has designed and is carrying out a rotational watershed assessment process over every five years. By focusing evaluations on selected basins each year, more systematic and intensive efforts can be made to collect and evaluate information related to the sources and causes of pollution. The monitoring year for each basin is shown in Figure 2 above.

Under the rotational monitoring and assessment process, DEC staff compile and evaluate all water quality and biological data and information; determine impacts to designated and existing uses; and document very high quality waters and aquatic habitat. Once the data and other information for each waterbody in a particular basin is assessed, a basin assessment report is prepared. The information contained in each basin assessment report is an early and vital piece of the basin planning process. Following completion of the basin assessment report, the basin planning process can stimulate more detailed assessments, propose re-classifications and/or typing, or outline protection or restoration activities that could be incorporated in a river basin water quality management plan. One or more assessment reports have been prepared for all of the basins.

River Watershed Assessment Reports and Updates

Basin	Original report written	Updated Assessment Report (s)
1 – Battenkill, Hoosic, Walloomsac	August 2002	Hoosic River Watershed December 2014
2 – Poultney, Mettawee Rivers	December 1999	January 2013
3/4 – Otter, Little Otter, and Lewis Creeks, Southern Lake Champlain	June 1998	
5 – Upper Lake Champlain	December 2003	Shelburne Bay Watershed June 2013 St. Albans Bay Watershed June 2013 Malletts Bay Watershed July 2013
6 – Missisquoi River	November 2004	Missisquoi Watershed August 2015
7 – Lamoille River	February 2001	Lamoille River Watershed February 2016
8 – Winooski River	April 2008	
9 – White River	November 1997	November 2002 July 2012
10 – Ottauquechee, Black Rivers	June 2000	
11 – West, Williams, Saxtons Rivers	November 2001	West River Watershed October 2014 Williams River Watershed October 2014 Saxtons River Watershed October 2014 Lower Connecticut R Tribs October 2014
12 – Deerfield River	March 2003	December 2012
13 – Lower Connecticut River	April 2002	The former basin 13 waterbodies are now part of Basins 10, 11, and 12
14 – Stevens, Wells, Waits, Ompompanoosuc	April 1999	Stevens River Watershed June 2014 Wells River Watershed August 2014 Waits River Watershed August 2014 Ompompanoosuc River Watershed Dec 2014
15 – Passumpsic River	June 2009	February 2013
16 – Upper Connecticut River	March 2011	
17 – Lake Memphremagog	March 2006	

Monitoring Designs to Collect Assessment Data

A full description of the Department's monitoring work is given in the Vermont Department of Environmental Conservation Water Quality Monitoring Strategy 2011 - 2020, May 2011. The strategy contains goals, objectives, and recommendations as well as complete descriptions of the various monitoring and assessment programs in the DEC Watershed Management Division.

Fixed Station Monitoring Approach

DEC coordinates a large number of fixed-station monitoring projects, incorporating river and lake water quality projects. Projects considered as fixed station in Vermont are long-term, recurring efforts that DEC has operated (or intends to operate) for several years. Some of these projects, such as the Ambient Biomonitoring Network and Lake Assessment Program (both of which incorporate several individual monitoring projects and studies) achieve dense statewide spatial coverage. The total number of river/stream and lake monitoring stations established under these two well-established programs exceed 1,650 and 650 respectively.

Fixed-station monitoring also includes monitoring done by other groups, schools or agencies. To be considered a part of the fixed-station approach, DEC must have knowledge of the particular monitoring plan (e.g. sampling site location, sampling frequency, parameters being collected and tested). Data generated by these other fixed-station monitoring efforts must have a quality assurance plan in order for DEC to characterize the data as reliable.

DEC's and the other fixed-station monitoring networks are designed to assess the status of current water quality conditions and to detect trends or changes in water quality condition. One of Vermont's major lake monitoring programs is a fixed-station, volunteer-based initiative.

Probability-based Monitoring Approach

Results from probability surveys are used to determine statewide water quality conditions in regard to use and provide statistically sound estimates of use attainment on a statewide or basin-wide basis. DEC recognizes the value of probability-based monitoring initiatives especially where predictability of use attainability is inherent in the project design. Such designs permit the use of statistically-derived models for inferring use attainment in appropriately selected waters where sampling was not performed.

DEC has incorporated probability sampling as part of its Water Quality Monitoring Program strategy, and such projects are linked to a larger national probability survey initiative. Probability surveys undertaken by DEC to date include:

- A REMAP assessment of mercury concentration in sediments, waters, and biota of 46 Vermont lakes and 47 New Hampshire lakes using a spatially randomized design (1998-2003).
- Characterization of use attainment for aquatic life using a spatially randomized draw of existing Ambient Biomonitoring Network data at varying site intensities (2001). The reader is referred to the Vermont 2002 Section 305b Report for a further description of this effort.
- A REMAP assessment of aquatic life use attainment in New England Wadeable Streams (2002-2006).
- Participation in the National Study of Chemical Residues in Fishes (2002-2005).

- Probability assessment of aquatic life use attainment in Vermont Streams based on a rotational basin design. The reader is referred to the Vermont 2008 Section 305b Report for a further description of this effort.
- Probability assessment of Vermont Lakes – 2007. The reader is referred to Vermont 2010 Section 305b Report for a further description of this effort.
- Probability surveys in conjunction with the USEPA through the National Aquatic Resources Surveys (NARS). These include the National Wetland Condition Assessment (2011), National Lakes Assessment (2012) and the National Rivers Assessment (2013).

Special Studies and TMDL-related Studies

DEC undertakes monitoring associated with special and Total Maximum Daily Load (TMDL) studies as needed, in response to compelling data and information supplied under the rotational assessment and fixed-station and probability-based projects. The number and nature of special studies is commonly dictated by the nature of issues and problems that are reported as needing further monitoring or that may arise as interest or funding permit. These types of studies include detailed sampling to assess use support or standards violations, diagnostic-feasibility studies, effectiveness evaluations of pollution control practices/measures and watershed-based surveys and evaluations. TMDL studies are scheduled as needed consistent with the timeline established in Vermont's 303d List of Waters and dependent on available resources.

Biological Monitoring and Assessments

Assessment of biological integrity is conducted on the state's rivers and streams for the purpose of trend detection, classification, evaluation of permitted activities and site-specific impact evaluation. Macroinvertebrate and/or fish populations of rivers and streams considered to be "wadeable" are assessed by comparing a series of biometrics measuring community structure and function to numeric criteria that represent the biological expectation for the stream type being evaluated. These numeric criteria directly interpret the narrative criteria for biota found in the Vermont Water Quality Standards.

Individual site surveys and subsequent processing steps are detailed in "*Methods for Determining Aquatic Life Use Status in Selected Wadeable Streams Pursuant to Applicable Water Quality Management Objectives and Criteria for Aquatic Biota Found in Vermont Water Quality Standards (WQS) Chapter 3, Section 3-01, as well as those specified in Section 3-02(A1 and B3), Section 3-03(A1 and B3), and Section 3-04(A1 and B4, parts a-d)*" (a.k.a. biocriteria procedure). Using the biocriteria procedures, the integrity of the aquatic biota is attributed a rank of excellent, very good, good, fair or poor. Rankings are indicative of aquatic life use support status for each water quality classification and water management type.

Sampled streams include both fish and macroinvertebrate assemblage collections where possible. Both community assessments must meet class criteria in order for a site/reach to comply with applicable standards. While information from both assemblages is desirable, an overall biological assessment declaring support or non-support of aquatic life uses can be made based on just one community alone. A determination of support - nonsupport is made only when data has been determined to be fully representative of the stream reach under consideration.

The biological potential for various sites has been established through statewide reference site monitoring. Information from this program element also serves to refine existing biocriteria and detect trends in baseline biological integrity. The long-term goal of reference site monitoring is to gather information on a set of known reference sites every year or every other year, so as to generate continuous data for each site. There are twenty-one of these long-term biological stream reference sites. Sites are stratified across stream ecotypes differing in drainage area size, elevation, and alkalinity. Human activity in reference site drainages is considered to be minimal relative to other streams in the ecoregion.

Where site-specific impact assessments are conducted (including an evaluation of the appropriate chemical and physical data), potential pollution sources that are not of natural origin are spatially bracketed (i.e. above and below) with sample sites to determine effects on the aquatic biota attributable to the pollution source. Either macroinvertebrate or fish populations or both may be sampled. Approximately 130 river sites are assessed each year in the late summer-early fall (September to October 15) on a five-year rotational watershed basis. DEC has evaluated over 1,650 sites since 1990.

The Department implements biocriteria only when appropriate reference conditions have been described. The Department recognizes differences between biological expectations for different types of waterbodies including lakes and ponds, wetlands, large and small rivers and perennial and intermittent streams. Management decisions are made accordingly.

VTDEC uses monitoring of fish and macroinvertebrates for direct assessment of aquatic life use attainment in streams. The lake assessment program began evaluating the status of selected biological species and communities in 1996 with the aim of developing numeric measurements to assess aquatic life use attainment in lakes. This initial effort led to the development of protocols for phytoplankton (VTDEC, 2003c) and macroinvertebrates (VTDEC, 2007). In 2009, further development of approaches for using macroinvertebrates ensued as part of the Littoral Habitat Assessment study. A Vermont and NEIWPC led regional lake biomonitoring workgroup continues to pursue the development of biocriteria for lakes.

Stream Geomorphic/Physical Habitat Assessment

Data collected during stream geomorphic assessments according to recognized procedures provide a better understanding of the physical processes and features shaping a watershed; help identify high quality habitat or habitat and aquatic communities that have been compromised; and contribute to understanding the effects of watershed land use activities on stream condition.

The Vermont Stream Geomorphic Assessment Protocols (DEC, 2003b) provide a method for assigning a geomorphic and physical habitat condition to stream reaches. The term “departure from reference” is used synonymously with stream geomorphic condition throughout the protocols. The degree of departure is captured by the following three terms:

A stream reach in *reference and good* condition that:

- Is in dynamic equilibrium which involves minor to moderate localized change to its shape or location while maintaining the fluvial processes and functions of its watershed over time and within the range of natural variability; and
- Provides very high to high quality aquatic and riparian habitat with persistent bed features and channel forms that experience periodic disturbance as a result of erosion, deposition, and woody debris.
- Aquatic communities are likely assessed as excellent to very good when sampled in a subset of the geomorphically assessed reach

A stream reach in *fair* condition that:

- Has experienced major changes in channel form and fluvial processes outside the expected range of natural variability; may be poised for additional adjustment with future flooding or changes in watershed inputs that would change the stream type; and
- Provides aquatic and riparian habitat that may lack certain bed features and channel forms due to increases or decreases in the rate of erosion and deposition-related processes.
- Aquatic communities are expected to be assessed in the “good to fair” range depending on whether the sample site reflects the erosional or deposition changes underway.

A stream reach in *poor* condition that:

- Is experiencing severe adjustment outside the expected range of natural variability; is exhibiting a new stream type; is expected to continue to adjust, either evolving back to the historic reference stream type or to a new stream type consistent with watershed inputs; and
- Provides aquatic and riparian habitat that lacks certain bed features and channel forms due to substantial increases or decreases in the rate of erosion and deposition-related processes. Habitat features may be frequently disturbed beyond the range of many species’ adaptability.
- Aquatic communities are likely fair- to- poor or poor. Aquatic biota sampling sites from previous years may not exist in the same location due to the stream type departure.

Phase 1 of the DEC protocols is the remote sensing phase and involves the collection of data from topographic maps and aerial photographs, from existing studies, and from very limited field studies. Geomorphic reaches and provisional reference stream types are established based on valley land forms and their geology. Predictions of channel condition (departure from reference), adjustment process, and reach sensitivity are based on evaluations of watershed and river corridor land use and channel and floodplain modifications.

Phase 2 of the protocols is known as the rapid field assessment phase and involves the collection of field data from measurements and observations at the reach or sub-reach (segment) scale. Existing stream types are established based on channel and floodplain cross-section and stream substrate measurements. Stream geomorphic condition, physical habitat condition, adjustment processes, reach sensitivity, and stage of channel evolution are based on a qualitative field evaluation of erosion and depositional processes, changes in channel and floodplain geometry, and riparian land use/land cover. At least Phase 1 and Phase 2 stream geomorphic data will be used in determining stressed or altered waters due to physical problems.

Phase 3 is the survey-level field assessment phase and involves the collection of detailed field measurements at the sub-reach or site scale. Existing stream types and adjustment processes are further detailed and confirmed based on quantitative measurements of channel dimension, pattern, profile, and sediments. Phase 3 assessments are completed with field survey and other accurate measuring devices.

Data Solicitation and Quality

In conjunction with each biennial assessment and reporting cycle, DEC solicits data to further enhance the quantity and spatial coverage of water quality data and other information that is used in assessing surface waters. The solicitation for water quality data is distributed to various watershed groups and is posted on the WSMD website (refer to <http://www.watershedmanagement.vt.gov>). The solicitation seeks data and information to be submitted by mid-November in odd-numbered years in order to be considered for the even- year reporting cycle. Data and other information submitted after that date will be considered for the next reporting cycle.

Data used must be of known quality and should be representative of the water's condition. All data generated by DEC in conjunction with WSMD monitoring programs are subject to quality assurance planning using USEPA quality assurance guidance. Moreover, any and all data generated in part or whole using funding from USEPA must be subject to a USEPA-approved quality assurance project plan (QAPP). All data generated in conjunction with any active and/or approved QAPP are considered readily available and reliable data (subject to data limitations identified in the quality assurance/quality control validation and verification process for each project), and are considered in determining use support. Data can be rejected from consideration in the event that it does not meet data quality objectives established by individual QAPPs. DEC's Quality Management Plan and Water Quality Monitoring Strategy provide listings of project-specific QAPPs. Guidance and assistance regarding quality assurance is also provided from the R.A. LaRosa Laboratory.

For data provided by organizations other than DEC and WSMD such as colleges, universities and citizen-based activities, data quality must be assured prior to considering it as the sole basis for use support. The number of samples, the length of the sampling period, the antecedent weather conditions, degree of compliance or violation and other factors are all considered when evaluating data from other organizations. Where data of unknown or unquantifiable quality are at odds with companion data of quantified quality, the higher quality data will be accorded higher weight in determining use support. Where data of unknown or suspect quality are the only information available, the waterbody is scheduled for additional monitoring prior to determining use support.

Vermont Surface Water Assessment Categories

Vermont's rivers, streams, lakes, and ponds have been categorized into "waterbodies" which serve as the cataloging units for the overall statewide assessment. Waterbodies are typically entire lakes, subwatersheds of river drainages or segments of major rivers. Using data that is quality assured along with other contextual information that is reliable, the Watershed Management Division determines whether each waterbody meets or does not meet Vermont Water Quality Standards, and

then places waters into one of four assessment categories, taking into account the waterbody classification and water management type. The four categories used in Vermont's surface water assessment are **full support**, **stressed**, **altered** and **impaired**. Waters that support designated and existing uses and meet Water Quality Standards are placed into the full support or stressed categories. Waters that do not support uses and do not meet standards are placed into the altered or impaired category. Waters can also be put into an **unassessed** category. These assessment categories are described below.

Full Support Waters

This assessment category includes waters of high quality that meet all use support standards for the water's classification and water management type.

In Vermont, there are many waters, such as intermittent streams, that are a lower priority for sampling visits given resource constraints, lack of public access or interest, and competing needs within DEC's water quality monitoring program. DEC therefore makes preliminary assessments, where practical, by considering five factors that address the likelihood that significant stressors exist within the subject watershed. Waters that meet all these factors are then considered to support their uses. The factors DEC uses to develop preliminary, screening-level assessments for these waters are:

- no discharges or contaminated sites in proximity to the waterbody;
- low probability of habitat degradation as evaluated by "Phase One" geomorphic assessments or other remote sensing evaluations;
- nearby sites have biological assessment findings compliant with Vermont Water Quality Standards, for like class and water management type;
- no problems are uncovered during outreach efforts associated with the rotational assessment process and basin planning; and
- no known water level manipulations.

Stressed Waters

These are waters that support the uses for the classification but the water quality and/or aquatic biota/ habitat have been disturbed to some degree by point or by nonpoint sources of human origin and the water may require some attention to maintain or restore its high quality; the water quality and/or aquatic habitat may be at risk of not supporting uses in the future; or the integrity of the aquatic community has been changed but not to the degree that the standards are not met or uses not supported. Data or other information that is available confirms water quality or habitat disturbance but not to the degree that any designated or existing uses have become altered or impaired (i.e. not supported).

Some stressed waters have documented disturbances or impacts and the water needs further assessment.

Altered Waters

These are waters where a lack of flow, water level or flow fluctuations, modified hydrology, physical channel alterations, documented channel degradation or stream type change is occurring and arises from some human activity, OR where the occurrence of exotic species has had negative impacts on designated uses. The aquatic communities are altered from the expected ecological state.

This assessment category includes those waters where there is a documentation of water quality standards violations for flow and aquatic habitat but EPA does not consider the problem(s) caused by a pollutant OR where a pollutant results in water quality standards not being met due to historic or previous human-caused channel alterations that are presently no longer occurring.

Impaired Waters

These are surface waters where there are chemical, physical and/or biological data collected from quality assured and reliable monitoring efforts (refer to section 5 of this chapter) that reveal 1) an ongoing violation of one or more of the criteria in the Water Quality Standards and 2) a pollutant of human origin is the most probable cause of the violation.

Unassessed Waters

Waters for which DEC has no monitoring data and only limited information and knowledge is available are considered unassessed.

Chapter Three. Assessment Use Support Determinations

The following pages provide specific criteria, principles for making decisions, and other information that DEC applies when making an assessment of water quality conditions and determining whether individual designated are fully supported, stressed, altered, impaired or unassessed. Information below is presented by each of the seven designated uses to show how relevant, representative and reliable water quality monitoring data and other information relates directly to the degree of use support for assessment reporting purposes. If not otherwise specified, the decision-making criteria apply to both streams and lakes.

Aquatic Biota/Habitat (Aquatic Life) Use

In assessing Aquatic Life Use, the DEC Watershed Management Division uses several types of water quality and water quantity data and information to determine use support. The specific data types are biological monitoring, habitat assessment, conventional pollutants, toxicants, and invasive aquatic species. For lakes, additional assessment guidelines are used to directly or indirectly assess uses using conventional pollutants, nutrients, and information regarding water-level impacts. Where there is biological (aquatic community) data then use support is determined by the assessment of that data even if conventional pollutant measures or habitat indicators are indicating otherwise. Specific decision-making criteria are as follows:

Biological Monitoring

Full Support: Biological assessments for fish and/or macroinvertebrate communities demonstrate compliance with appropriate threshold criteria as described in DEC biocriteria implementation methodologies. In the absence of applicable biocriteria, all available information and data are used to make scientifically defensible weight-of-evidence findings that designated aquatic life uses are fully supported. In most cases, biological condition ratings of *excellent*, *very good*, and *good* will indicate full support status for Class A(1), Class B(1), and Classes A(2) B, B(2) and B(3) respectively.

Stressed: Biological assessments for fish and/or macroinvertebrate communities and/or habitat assessments indicate that impacts have occurred but are inconclusive with regard to support status determination or demonstrate that the biological condition is at risk of making a transition between support and non-support. In the absence of applicable biocriteria, all available information and data are used to make scientifically defensible weight-of-evidence findings that designated aquatic life uses are stressed. Additional biological assessment may be needed. In most cases, biological condition ratings of *“excellent-to-very good”* will indicate stressed status for Class A(1) waters, *“very good-to-good”* will indicate stressed status for Class B(1) waters; *“good”* or *“good to fair”* will indicate stressed status for Class B waters and *“good-to-fair”* will indicate stressed status for Class A(2), B(2) and B(3) waters.

Altered: Biological assessments for fish and/or macroinvertebrate communities demonstrate non-compliance with appropriate threshold criteria as described in DEC biocriteria implementation methodologies and the cause is not a pollutant (e.g. flow regulation or non-native species). In the absence of applicable biocriteria, all available information and data are used to make scientifically

defensible weight-of-evidence findings that designated aquatic life uses are not fully supported. In most cases, biological condition ratings of *very good or lower*, *good or lower*, and *fair or lower* will indicate altered status for Class A(1), Class B(1), and Classes A(2), B, B(2) and B(3) respectively. Generally, biological data indicating non-attainment from the previous two or more successive samples are necessary in order to determine this condition.

Impaired: Biological assessments for fish and/or macroinvertebrate communities demonstrate non-compliance with appropriate threshold criteria as described in DEC biocriteria implementation methodologies and the cause is due to a pollutant of human origin. In the absence of applicable biocriteria, all available information and data are used to make scientifically defensible weight-of-evidence findings that designated aquatic life uses are not fully supported. In most cases, biological condition ratings of *very good or lower*, *good or lower*, and *fair or lower* will indicate impaired status for Class A(1), Class B(1), and Classes A(2), B, B(2) and B(3) respectively. Generally, biological data indicating non-attainment from the previous two or more successive samples are necessary in order to determine this condition.

Habitat Assessment

Full Support: Depending on the water's classification and typing {A(1), A(2), B, B(1), B(2), B(3)}, very high or high quality habitat with up to a moderate change from natural or reference condition exists "consistent with the full support of all aquatic biota and wildlife uses."

Stressed: Stream or river physically under stress – in adjustment with stresses greater than as naturally occurs to a "fair" condition derived from a geomorphic assessment completed using recognized protocols.

Altered: Changes to the habitat are greater than minimal to a moderate change from reference, depending on the water's classification and typing. There is an undue adverse effect on the physical nature of the substrate. Aquatic habitat surveys show significant deviation from the reference condition due to human-caused changes and/or geomorphic assessment indicated "fair" to "poor" conditions. All life cycle functions, including over-wintering and reproductive requirements, are not adequately maintained and protected due to the physical habitat changes.

Impaired: A pollutant of human origin is shown to cause more than the allowable change to aquatic habitat as defined by Vermont Water Quality Standards.

Conventional Pollutants (temperature, pH, D.O., turbidity, phosphorus, nitrate-nitrogen.)

Streams and Lakes

Full Support: Waters that are not stressed or impaired due to conventional pollutants, assessed using the Vermont Water Quality Standards. For example, the total increase from the ambient temperature due to all discharges and activities is not known to exceed 1.0 degree F for a coldwater fishery and the total increase from ambient temperature due to all discharges and activities shall not exceed the temperature criteria derived from tables 1 or 2 in Section 3-01.B.1.c. except as provided for in Section 3-01 B.1.d. of the Vermont Water Quality Standards (pertaining to both a coldwater and warmwater fishery).

Stressed: Waters where the level of a conventional pollutant or a combination of conventional pollutants of human origin may be resulting in some disturbance. For example, temperatures are such that in coldwater fishery waters, one or more trout species are reduced in number or biomass as compared to reference condition. Waters with alkalinities between 2.5 and 5.0 mg/l (as CaCO₃), and pH values may occasionally drop below 6.5. Coldwater fishery waters where dissolved oxygen may be between 6 and 7 mg/l and 75 to 85% saturation.

Altered: This assessment category is not used in this context.

Impaired:

Temperature: Temperatures are too high as a result of human activities to fully support coldwater fish species in waters designated as a coldwater fishery OR the total increase from the ambient temperature due to all discharges and activities exceeds 1.0 F for a coldwater fishery and the total increase from ambient temperature due to all discharges and activities exceeds the temperature criteria derived from tables 1 or 2 in Section 3-01.B.1.c. except as provided for in Section 3-01 B.1.d. of the Vermont Water Quality Standards (pertaining to both a coldwater and warmwater fishery).

Acidity: Reliable, representative monitoring indicates that pH values repeatedly fall below 6.5 standard units or exceed 8.5 standard units across a range of weather conditions, and values are not due to natural sources.

Dissolved oxygen: Reliable, representative monitoring indicates D.O. values or percent saturation repeatedly fall below the standard for the water's classification and type except as noted below.

Turbidity: Reliable, representative monitoring shows that the mean turbidity values are above the standard for a water's classification and type as measured at or below low median monthly flows and values are not due to natural sources.

Nitrates: Reliable, representative monitoring shows that nitrate-nitrogen repeatedly and/or consistently exceeds the standard for the water's classification, type, and elevation as noted in VWQS Section 3-01.B.3.

Combined Nutrient Criteria: For all lakes save Lakes Champlain and Memphremagog, and all streams and rivers save non-wadeable rivers, reliable, representative monitoring shows that mean phosphorus concentrations repeatedly and/or consistently exceed the criteria contained in Tables 3, 4, or 5 of Section 3 of the Vermont Water Quality Standards. Consistent with the Technical Support Document for nutrient criteria, and for lakes and reservoirs only, the Department may not require consistency with Aquatic Biota, Wildlife, and Aquatic Habitat provisions of Tables 3, 4, or 5.

Phosphorus: For Lakes Champlain and Memphremagog, reliable, representative monitoring shows that mean phosphorus concentrations repeatedly and/or consistently exceed the criteria contained in Table 6 of Section 3 of the Vermont Water Quality Standards.

Lakes Only – Alkalinity and D.O.

Full Support: Waters that are not stressed or impaired.

Stressed: Reliable long-term monitoring data indicates that a lake's alkalinity routinely drops below 12.5 mg/l (as CaCO₃) during the spring runoff period.

Reliable long-term monitoring data indicates that a lake's hypolimnetic dissolved oxygen concentration periodically falls to (or near) 0 mg/l or 0% saturation during peak summer stratification, but macroinvertebrates are present. The area designated as stressed, as a result of human disturbance, is limited to the lake acreage underlain by the hypolimnetic oxygen-deficient area.

Altered: This assessment category is not used in this context.

Impaired: Reliable monitoring data indicates that alkalinity routinely drops below 2.5 mg/l (as acid neutralizing capacity) during the spring runoff period.

Reliable monitoring data indicates that a lake's hypolimnetic dissolved oxygen concentration falls to (or near) 0 mg/l or 0% saturation for a period of greater than 50% of the summer stratification period, **and** the hypolimnetic sediments are devoid of a macroinvertebrate community. The area designated as impaired, as a result of human disturbance, is limited to the lake acreage underlain by the hypolimnetic oxygen-deficient area. However, if in the best professional judgement of DEC scientists, the dissolved oxygen deficit is due to natural causes, aquatic life uses will be considered instead as fully supported.

The epi- and metalimnetic lake waters will be considered impaired if dissolved oxygen concentrations fall below Water Quality Standards in greater than or equal to 10% of samples, and the anoxia is not a natural phenomenon.

Reliable monitoring data indicates nitrates in excess of 5.0 mg/l in 10% or more of samples collected.

A minimum of four evenly-spaced sampling events across the summer stratification period are commonly used to make a determination regarding conventional pollutants in lakes, except for alkalinity, which is most commonly measured in spring, which corresponds to peak acidity loading for lakes.

Toxicants (priority pollutants, metals, chlorine & ammonia)

All Toxics but Chloride (addressed below)

Full Support: Waters that are not stressed or impaired due to toxicants, as described below.

Stressed: Water quality monitoring or sediment samples reveal the presence of toxics below criteria or there are no relevant criteria and the source of the pollutants has not been remediated. Groundwater data in wells adjacent to the stream shows levels of pollutants above the Vermont Groundwater Enforcement Standards but no in-stream data exists or no sediment samples have been taken.

Altered: Toxicants are considered pollutants, therefore, the category "altered" is not applicable.

Impaired: In most cases, the following exposure presumptions are applicable to compliance determinations: for any one pollutant, an acute aquatic biota criterion is exceeded more than once

within a 3-year period, for longer than one hour, above ten-year, seven-day flow minimum (7Q10) flows; or a chronic aquatic biota criterion is exceeded for more than four consecutive days in a three year period, above 7Q10 flows.

(DEC recognizes that the literal interpretation of the exposure scenario cited would be difficult to replicate in a field situation. The language cited reflects the exposure conditions used to develop the numerical criterion that is the water quality standard. It is likely that available monitoring data would be collected under a variety of temporal and spatial formats. In evaluating data, DEC uses the exposure assumptions of the criterion development as guidelines in the interpretation of data and uses empirical and judgmental means to assess whether or not there is reasonable potential for those exposure assumptions to be violated. Given the variable nature of available information, evaluations will vary on a case-by-case basis. DEC takes into consideration guidance provided by EPA when evaluating toxicants in surface waters (see “Technical Support Document for Water Quality-based Toxics Control.” EPA/505/2-90-001).

Chloride

Full support: No exceedances in excess of chronic criterion of 230 mg/l.

Stressed: One or more exceedances of the chronic criterion for any given 3 year period or evidence of consistently elevated chloride levels. The determination of “elevated chloride levels” will be assessed on a case by case basis. Where available, biomonitoring information will be evaluated to assist in the aquatic life use assessment. The water will be assessed as stressed and flagged for follow-up monitoring, likely the development a continuous dataset.

Impaired:

Chronic criterion:

Grab Samples: Given the duration and frequency terms of the chronic criteria, limited numbers of chloride grab samples will rarely be sufficient to document the four-day average over a three year period. Surface waters with multiple samples above the criterion will direct the need for follow-up monitoring, using a continuous dataset. However, if a sufficiently large chloride dataset exists to confidently calculate any unique 96 hour average exceeding the criterion, then the water will be assessed in non-support.

Continuous Monitoring Using Conductivity: Where continuous monitoring datasets indicate an average chloride concentration in excess of 230 mg/L for more than one 96 hour period in a three-year period, the waterbody will be assessed in non-support (See Appendix A).

Acute Criterion:

Grab Samples: A minimum of 2 samples, separated by one hour, that exceed 860 mg/L for any given 3-year period.

Continuous Monitoring Using Conductivity: Where continuous monitoring datasets indicate an average chloride concentration in excess of 860 mg/L for more than one hour in a three-year period, the waterbody will be assessed in non-support.

Invasive Non-native Species

Invasive non-native species such as Eurasian watermilfoil (*Myriophyllum spicatum*), water chestnut (*Trapa natans*), alewives (*Alosa pseudoharengus*) or zebra and quagga mussels (*Dreissena spp.*) have significant impacts on existing aquatic plant and animal communities. Information on the extent and distribution of these species is used to assess aquatic life use support.

Full Support: No established population of an invasive non-native species.

Stressed: Invasive non-native species are present but in low densities (e.g. scattered areas of plant growth in limited areas of the littoral zone). In the case of Eurasian milfoil, lakes within a 10-mile radius of an infested lake are considered stressed, unless access to the lake is remote or inaccessible by conventional means.

Altered: Invasive non-native species present in densities sufficient to alter native biological communities. For example, overall plant density is classified as “moderate,” indicating locally abundant (50% or greater coverage) growth, or “heavy,” (75% or greater littoral cover overall) indicating growth in most shoreline areas.

Impaired: Invasive non-native species are not considered pollutants. Therefore, this category is not applicable.

Fluctuated Reservoirs and Lakes

Reservoirs present special cases in regards to assessment of aquatic life use support (ALUS). In the absence of direct biological measurements beyond routine aquatic plant survey data, ALUS can be assessed using the following decision-making ‘tree.’ In order to use this decision tree, several pieces of information regarding the reservoir are useful. These include bathymetry, maximum and mean waterbody depth, the limnological shoreline development index, and the magnitude and timing of the drawdown. These data can be used collectively to estimate the proportion of the littoral zone likely to be affected by the drawdown regimen. Where available, biological data (in particular the presence and distribution of aquatic macrophytes within the littoral zone) are also useful.

- 1) Can the level of the waterbody be regulated by an artificial structure (e.g. dam, sluice, weir)?
Answer is NO: no alteration or stress to ALUS due to water level fluctuation. **Full Support.**
Answer is YES: go to 2.
- 2) Is the waterbody connected to a licensed or unlicensed hydroelectric generating system, a flood control system, or subject to promulgated Vermont Water Resources Board rules regulating the fluctuation?
Answer is NO: a stress or alteration to ALUS could potentially exist, but must be verified by direct assessment before the waterbody can be correctly assessed; go to 4.
Answer is YES: go to 3.
- 3) Is the waterbody regulated by a federal Clean Water Act Section 401 water quality certification issued by VTDEC after January 1, 1990?
Answer is NO: go to 4.

Answer is YES: ***no alteration or stress to ALUS due to water level fluctuation if operated in accordance with the license.***

- 4) Is the waterbody in fact subject to periodic fluctuations that are attributable to operation or manipulation of the outflow structure?

Answer is NO: ***a stress to ALUS is presumed to exist***, due to the ability of the outflow operators to fluctuate water levels if the need arises, which can negatively impact littoral zone communities. Such littoral zone impacts have the potential to cause cascading changes within the trophic web of the waterbody but cause no more than a minor change in habitat or moderate change in aquatic biota from the reference condition. The entire waterbody acreage will be assessed as stressed for ALUS.

Answer is YES: Go to 5.

- 5) Does there exist a sufficient area of littoral habitat below the drawdown zone to enable establishment of a viable and stable aquatic community, with all expected functional groups, while accommodating the drawdown regimen, **or**, does available biological data suggest that such a community exists within the drawdown zone?

Answer is NO: ***ALUS is altered***. These alterations create more than a moderate change to aquatic habitat. Littoral zone impacts of this magnitude will have cascading impacts throughout the trophic web, resulting in more than a moderate change in aquatic biota from the reference expectation. Aquatic macroinvertebrate and fish assemblages exhibit more than moderate changes in the relative proportions of tolerant, intolerant, taxonomic and functional components. Accordingly, the entire acreage is assessed as altered.

Answer is YES: ***ALUS is stressed***. These stresses cause no more than a moderate change to aquatic habitat. Littoral zone impacts of this magnitude could have cascading effects within the trophic web of the waterbody, but these are presumed to create no more than a moderate change to aquatic biota from the reference expectation based on the relative proportions of tolerant, intolerant, taxonomic and functional groups. The waterbody's entire acreage is presumed to be stressed for ALUS.

Fish Consumption Use

Vermont interprets the U.S. EPA guidance on fish consumption use attainment to indicate that no waters fully support fish consumption. This is due to well-documented contamination of varying levels of lakes by mercury in waters, sediments, and aquatic biota arising from atmospheric deposition. In the tissues of fish inhabiting Lake Champlain (and elsewhere), other contaminants including polychlorinated biphenyls, polyaromated hydrocarbons, and "DDT" derivatives, have been identified.

DEC does not, however, subscribe to the notion that fish tissue consumption is impaired on a statewide basis. This is because most fish species can, indeed, be consumed from most Vermont waters, albeit at a reduced rate. Fish consumption use is considered impaired only in the event that the fish species subject to the consumption advisory is documented to exist in the waterbody and contaminant data exist for that species from the particular waterbody. This approach is consistent with current EPA guidance.

Full Support: No fish consumption advisory in effect.

Stressed: "Restricted consumption" of fish is in effect (restricted consumption is defined as limits on the number of meals or size of meals consumed per unit time for one or more fish species).

Altered: Tissue contaminants are derived from the deposition or release of pollutants into the aquatic environment. Accordingly, this assessment category is not relevant.

Impaired: Fish consumption use is considered impaired only in the event that the fish species subject to the consumption advisory is documented to exist in the waterbody and contaminant data exist for the species from the particular waterbody. For a given fish species present in a waterbody, a 'no-consumption' advisory is in place for a designated sub-population (e.g., children or women of childbearing age) or for the general population.

Swimming/Contact Recreation Use

For assessment of Swimming/Contact Recreation Use, the DEC Watershed Management Division uses one or more types of data to determine whether this use is supported. The specific data types are bacterial monitoring, invasive aquatic species growth, and on rare occasion, the presence of chemical contaminants. Decision-making criteria are as follows:

Indicator Bacteria

To assess waters for support of swimming and contact recreation using *E. coli* monitoring data, a minimum number of data points are necessary, and supporting contextual data such as antecedent weather and flow conditions must be considered. DEC considers at least five (5) reliable and quality assured sample results over a swimming season and gathered across a range of weather/flow conditions to be the minimum practical number of samples necessary to document representative conditions and to assess attainment of contact recreational uses. In a practical sense, weekly or more frequent *E. coli* data across the swimming season is most useful to determine impairment and observe weather-related patterns in bacterial concentrations. If there are questions regarding the representativeness of the data, the water is identified as needing monitoring and is recommended for follow-up *E. coli* sampling in the next season.

Vermont's standards for bacteria now are similar to those recommended by EPA. In Class A waters, *E. coli* not to exceed the geometric mean of 126 organisms /100 ml obtained over a representative period of 60 days and no more than 10% of samples above the statistical threshold value of 235 organisms/100ml with none attributable to the discharge of wastes are the criteria. It is the same for Class B waters, except for the preclusion of treated waste, and with criteria in a shorter averaging period for waters receiving CSOs.

The following guidelines are applied during the assessment process:

Full Support: Waters are suitable for swimming with generally low *E. coli* values.

Stressed: Individual samples occasionally exceed the class-specific single-sample criteria values following a rain event. The geometric mean does not exceed the criterion value.

Altered: *E. coli* indicator bacteria are considered a pollutant. This assessment category is not applicable.

Impaired: For class B waters, the geometric mean of 126 *E. coli* /100 ml is exceeded in a given segment or area and/or more than 10% of the samples are above 235 organisms/100 ml. The contamination must be attributable to sources other than natural sources. DEC accepts a weight-of-evidence approach to confirm that *E. coli* values are or are not of natural origin. The WQS state that samples should be obtained “over a representative period of 60 days” and “in water receiving combined sewer overflows, the representative period shall be 30 days”. However, at least five samples collected regularly over the representative period is recommended, and flow and antecedent precipitation are important in this determination.

For class A(1) and A(2) waters, the geometric mean exceeds 126 *E. coli* /100ml over a representative period of 60 days and/or more than 10% of the samples are above 235 organisms/100ml. No elevated *E. coli* can be “attributable to the discharge of wastes”. Generally, data from at least two swimming seasons are needed to assess waters as impaired for swimming.

Alternatively, waters with CSOs present that do not meet DEC’s 1990 CSO Control Policy are considered impaired for swimming without the direct water *E. coli* sampling numbers (per the sampling parameters described above).

Nuisance and Invasive Aquatic Species

Full Support: Waters have native plant species and communities as would be expected and in good ecological balance. Waters are not stressed or altered by invasive non-native aquatic species.

Stressed: Invasive non-native species are present but not at levels where a nuisance has been documented or in “light” densities (scattered areas of growth in limited areas of the littoral zone). In the case of Eurasian milfoil, lakes within a 10-mile radius of an infested lake are considered stressed, unless access to the lake is remote or inaccessible by conventional means.

Altered: Invasive non-native species present in densities such that swimming uses are not met. For aquatic macrophytes, typically these conditions are characterized by greater than 75% cover of the non-native macrophyte and designated as “moderate” or “heavy” infestations. For species other than aquatic macrophytes such as zebra mussels, colonies would be present in such densities and at such depths as to impact swimming uses due to potential for injury to bare feet. Nutrients are not applicable in this category.

Impaired: An on-going record of public complaint concerning the algal conditions in the water has been established. For cyanobacteria (blue-green algae), regular, reliable monitoring indicates that cyanobacteria routinely exceed guidelines established by the Vermont Department of Health for recreation . Invasive non-native aquatic species are not applicable in this category.

Chemical Contamination

Water quality criteria do not address incidental/accidental ingestion of water or dermal exposure to recreational users where there is chemical contamination present. Chemical contamination can enter surface waters or be deposited on beaches from both natural and anthropogenic sources. These may be point sources, such as municipal and industrial outfalls, or nonpoint sources such as runoff from land or leaching from old hazardous waste sites. In most cases there will be significant dilution or attenuation of contaminants.

Drinking water guidelines can provide a starting point for deriving values that could be used to make a screening level risk assessment. It has been suggested (WHO Guidelines for Safe Recreational Waters 2009) that water quality standards for chemicals in recreational waters should be based on the assumption that recreational water makes only a minor contribution to intake.

It is assumed that contribution of swimming is equivalent of 10% of drinking-water consumption. Based on drinking water consumption value of 2 liters a day, this would result in an intake of 200ml per day from recreational contact with water. A simple screening approach therefore would be that a substance occurring in recreational water at a concentration of ten times the drinking water guidelines (VDOH Drinking Water Guidance) is considered stressed and needs further assessment.

Organic contaminants can be present in surface waters from industrial and agricultural activity. EPA studies have shown that dermal contact and inhalation can contribute as much as water ingestion. Many of these are associated with sediments and particulate matter. Consideration should be given to the possibility of sediment being disturbed and ingested by infants and young children. EPA Regional Screening Levels (RSL) for Residential Soil can be used to screen sediment chemistry data from a site. If the screening value is exceeded, it suggests the need for specific evaluation of the contaminant taking local circumstances into consideration.

Full Support: No chemical contamination present in sediments or surface waters at any level of concern.

Stressed: A chemical is present in surface water samples at a concentration that is ten times the Vermont Department of Health Drinking Water Guidance. Or, for dermal exposure to the contaminants in sediments, the EPA Regional Screening Levels for Residential Soils are exceeded. Further assessment is needed following exceedance of screening levels.

Altered: This category is not used under these situations.

Impaired: A water is part of a Superfund site or other Hazardous waste site where special health and safety training and precautions are required to access the site or the public is restricted access from all activities including swimming, fishing and trespassing for health and safety reasons by an entity such as the Vermont Department of Health.

Secondary Contact/Non-Contact Recreation Use

For assessment of Secondary Contact/Non-Contact Recreation Use, the DEC Watershed Management Division uses information regarding water quantity and water quality, data and other information regarding the game fishery and records of public feedback and complaint to determine levels of support.

Full Support: Water quantity and quality sufficient for boating and fishing.

Stressed: Odor, color, plant growth, low water conditions occasionally discourage boating or fishing.

Altered: Fishing and/or boating are limited due to insufficient or diminished or lack of water, aquatic nuisance species or channel alterations. Boating is not feasible to the degree deemed achievable for the water's Water Management Type.

Impaired: Fishing and/or boating are limited due to water quality or aquatic habitat impairment(s) caused by pollutants from human sources.

Drinking Water Supply Use

Drinking water supply use is assessed using data on toxicants and bacteria; information on water treatment plant operation and operating costs; and, data describing cyanobacterial (blue-green algae) toxin concentrations.

Full Support: Water quality suitable as a source of public water supply with disinfection and filtration.

Stressed: This category is not applicable.

Altered: A well-established zebra mussel infestation or frequent cyanobacteria blooms are known to increase cost or effort to produce water that is suitable for drinking.

Impaired: In rivers, streams, brooks and riverine impoundments the exceedance, due to human sources, of any one human health-based toxic pollutant criteria listed in Appendix C of the Water Quality Standards (or as otherwise determined by the Natural Resources Agency Secretary in accordance with the Toxic Discharge Control Strategy) at flows equal to or exceeding the median annual flow for toxic substances that are classified as "non-threshold toxicants" or at flows meeting or exceeding the 7Q10 flow for toxic substances that are classified as "threshold toxicants." In all other waters, the exceedance, due to human sources, of any one human health-based toxic pollutant criteria listed in Appendix C (or as otherwise determined by the Secretary in accordance with the Toxic Discharge Control Strategy) at any time. (Note: "non-threshold toxicants" are probable or possible human carcinogens and "threshold toxicants" are not known or probable human carcinogens).

Criteria established by the Federal Safe Drinking Water Act can be met only by employing treatment practices that operationally or financially supercede customary practices that include filtration and disinfection.

Aesthetics Use

For assessment of Aesthetic Use, the DEC Watershed Management Division uses water quality and water quantity information from field surveys for rivers and streams and public feedback and complaints as well as field surveys for lakes and ponds to determine levels of support.

Full Support: Water character, flows, water level, riparian and channel characteristics, all exhibit good to excellent aesthetic value consistent with the waters classification. Water clarity and substrate condition is good. No floating solids, oil, grease, scum, or algae blooms. Limited or no record of public concern.

Stressed: Aesthetic quality is compromised somewhat. Water unnaturally turbid at times. Moderate levels of invasive, non-native plant growth. Small or disturbed riparian zone. Some record of public concern or complaint.

Altered: Aesthetic quality is poor due to a diminished amount of water to no water in the channel or lake resulting from human activities or due to moderate or heavy densities of invasive, non-native species. Streambanks are severely slumping, stream is braided, channel is highly straightened and rip-rapped, and channel bed material is severely jumbled and unsorted.

Impaired: Aesthetic quality of water is poor. Water is frequently and unnaturally turbid. Substrate is unnaturally silt-covered, mucky, or otherwise changed so as to adversely affect the aesthetics in an undue manner. Presence of solid waste, floating solids, scum, oil or grease occurs frequently and persistently. Rocks are unnaturally colored by metal contamination.

Agricultural Water Supply Use

There are no EPA definitions for agricultural water supply nor any state definitions and criteria. Consequently, this use is unassessed and the four assessment categories are not used.

Chapter Four. Listing and De-Listing Methodology

For the purposes of identifying and tracking important water quality problems where the VTWQS are not met, VTDEC has developed the Vermont Priority Waters List. This list is composed of several parts each identifying a group of waters with unique water quality concerns. Development of each part is guided by various regulations and/or management considerations including federal Clean Water Act requirements, EPA guidance or Vermont-specific management objectives. This list is produced biannually on even numbered years. Table 2 outlines the composition of the Priority Waters List while specific details of each list's composition are given below.

Table 2. Summary of Vermont Priority Waters List

List Section	Assessment status	Description
Part A (303d List)	Impaired	Also known as the §303(d) Impaired Waters List. This federally mandated list identifies impaired waters scheduled for TMDL development
Part B	Impaired	Waters assessed as impaired for which TMDLs are not required
Part D	Impaired	Impaired waters that have completed and EPA approved TMDLs
Part E	Altered	Waters assessed as altered due to the presence of invasive species
Part F	Altered	Waters assessed as altered due to flow regulation

Impaired Waters

All waters determined to be impaired are placed on Part A (303d List), Part B or Part D.

Part A - 303d List

Part A of the Priority Waters List identifies impaired surface waters that are scheduled for total maximum daily load (TMDL) development. Part A of the List is prepared in accordance with current EPA guidance and federal regulations 40CFR 130.7 ("Total maximum daily loads (TMDL) and individual water quality-based effluent limitations"). A TMDL is required for these waters in order to establish the maximum amount of a pollutant that may be introduced into the water after the application of required pollution controls and to ensure the Water Quality Standards are attained and maintained.

In addition to identifying the waterbody, Part A identifies the pollutant(s) causing the impairment, the priority ranking for TMDL development, which water use(s) are impaired and a brief description of the specific water quality problem.

Identification of Pollutant

The federal regulation governing 303(d) List development, 40CFR §130.7(b)(4), requires states to include the "pollutants causing or expected to cause violations of the applicable water quality standards". This pollutant then becomes the basis for TMDL loading allocations or for the control measures necessary to bring about compliance.

Where there is monitoring data that identifies a violation of numeric criteria, identification of the pollutant is evident. For example, long-term monitoring data may identify a segment of Lake Champlain as exceeding the numeric criterion for total phosphorus. Other numeric criteria are less indicative of the specific pollutant as in the instance of a dissolved oxygen criteria. The numeric criterion in this instance can be measured (low dissolved oxygen) but the pollutant causing that condition is not directly identified. Where there is monitoring data that identifies a violation of a narrative standard, the identification of the causal pollutant becomes more complex. An example is where biomonitoring data indicates a violation of the biocriteria for aquatic life use support.

In the instance of a biocriteria violation, VTDEC attempts to be as accurate as possible in identifying the causal pollutant. Where appropriate, VTDEC subscribes to EPA's Stressor Identification Methodology (USEPA, 2000b) or similar process. These assess site specific stressors and indicators such as biological and habitat indicators, land use information, proximity of known pollutant sources or other relevant information to identify by inference the most probable causal pollutants or stressors. This process can provide a defensible list of pollutant stressors or suite of stressors of common origin as in the case of runoff from impervious surfaces (i.e. stormwater).

At times, however, it may be necessary to identify a water as impaired without providing a specific causal pollutant. In these instances the pollutant is identified as "undefined".

TMDL Scheduling

Priority ranking for TMDL development is done with consideration of many factors. These include but are not limited to: (1) health issues, (2) the nature, extent, and severity of the pollutant(s), (3) the use or uses that are impaired, (4) the availability of resources and methods to develop a TMDL, (5) the degree of public interest, and (6) the utility of TMDL development to the elimination of the impairment.

Public Comment Opportunity, Submittal to EPA and EPA Approval

Upon compilation of the draft Part A-303d List, it is made available to the public for review and comment. Notification of availability is at a level sufficient to allow broad coverage of the general public and may include notices in newspapers, web sites and direct notification through email or mailing lists. In addition to notification, public meetings may be conducted to further the public's understanding. Following receipt of public comments, a response summary is developed that describes how the comments were addressed. Appropriate changes are made to the list and a final version of the Part A-303d List is then sent to the New England regional office of EPA for review and approval.

De-listing - Interim List

During development of new Part A-303d Lists, there may arise the need to propose for de-listing water(s) identified on previous lists. In this instance, waters proposed for de-listing are presented on the Interim List. This list is termed "interim" because it only exists during the period of Part A-303d List development in order to notify the public and EPA of de-listing proposals and to provide the rationale and justification for such proposals.

On the Interim List, each entry contains specific information for that particular waterbody as to why it is being proposed for de-listing. The waterbody-specific rationale is intended to provide "good cause" for de-listing and may be based on the following determinations:

- Assessment and interpretation of more recent or more accurate data demonstrate that the applicable WQS(s) is being met.

The absence of impairment can be substantiated by data of a comparable quantity and quality as the data that was required to assess the water as impaired (for example, 2 years of biological or chemical data needed to establish impairment generally means 2 years of data needed to establish attainment).

- Flaws in the original analysis of data and information led to the segment being incorrectly listed.
- Documentation that a water included on a previous Part A-303(d) List was not required to be listed by EPA regulations, e.g. segments where there is no pollutant associated with the non-compliance
- A determination pursuant to 40 CFR 130.7(b)(1)(iii) that there are other pollution control requirements required by state, local or federal authority that will result in attainment of WQSs for a specific pollutant(s) within a reasonable time.

In order to de-list these impaired waters from Part A, VTDEC must be convinced that other pollution control requirements, such as best management practices, will result in the attainment of Vermont Water Quality Standards. Specifically, DEC needs to show that (1) there are legal requirements in place (e.g. regulations, permits implementing regulations) that apply to the source(s) causing the water quality impairment and (2) that such legally required pollution control practices are specifically applicable to the impairment in question **and** are sufficient to cause the water to meet water quality standards within a reasonable time. These waters are then listed on Part B of the Vermont Priority Waters List.

- Approval or establishment by EPA of a TMDL since the last Part A-303(d) List. These waters are then listed in Part D of the Vermont Priority Waters List.
- Other relevant information that supports the decision not to include the segment on the Part A-303(d) List

Part B List

All waters listed in Part B are assessed as impaired and do not require development of a TMDL as described in 40 CFR 130.7. Impaired waters that do not need a TMDL are those where other pollution control requirements (such as best management practices) required by local, state or federal authority are expected to address all water-pollutant combinations and the Water Quality Standards are expected to be attained in a reasonable period of time. DEC will provide information to show that (1) there are legal requirements in place (e.g. regulations or permits implementing regulations) that apply to the source(s) causing the water quality impairment and (2) that such legally required pollution control practices are specifically applicable to the impairment in question **and** are sufficient to cause the water to meet water quality standards within a reasonable time. Additional discussion of the Part B requirements are given in the EPA Integrated Report guidance document (USEPA 2005).

Part D List

All waters identified on Part D are assessed as impaired and have completed and approved TMDLs. If future assessments show the impairment has been eliminated, the waters will be removed from the Part D List. A comprehensive list of completed TMDLs is maintained on the Watershed Management Division's website.

Altered Waters

All waters determined to be altered are placed on one of several lists that track altered waters. These lists include: Part E List (water altered by invasive non-native species), and Part F (waters altered by flow regulation). The listing methodology for each list is given below.

Part E List

Waters appearing in Part E are assessed as "altered." They represent situations to be given priority for management where aquatic habitat and/or other designated uses have been altered to the extent that one or more designated uses are not supported due to the presence of aquatic invasive species. Waters will be removed from the Part E List when the population of the aquatic invasive species declines or is eliminated and the water is assessed as either "stressed" or in "full support" of the designated uses.

Part F List

Waters appearing in this part of the Vermont Priority Waters List are assessed as "altered." They represent priority management situations where aquatic habitat and/or other designated uses have been altered by flow regulation to the extent that one or more designated uses are not supported. Alterations arise from flow fluctuation, obstructions, or other manipulations of water levels that originate from hydroelectric facilities or other dam operations or from water withdrawals for industrial or municipal water supply or snowmaking purposes.

Waters will be removed from the Part F List as corrective actions are implemented.

Stressed Waters

Stressed Waters List

The Stressed Waters List identifies waters that have been assessed as "stressed". In the event a future assessment indicates non-compliance with the VTWQS, DEC will assess the water as "impaired" or "altered," depending on whether or not the cause of the violation is a pollutant, and place it on the appropriate part of the Priority Waters List.

Full Support Waters

Waters that fully support designated uses are not tracked on the Vermont Priority Waters List.

Comparison to EPA's Listing Categories

In 2005, the USEPA issued guidance (*"Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act"*) to provide states a recommended reporting format and suggested content to develop a single document that integrates the reporting requirements of Clean Water Act section 303(d) and 305(b). Known as the "Integrated Report", it is EPA's strategy to report on water quality standards attainment of assessed waters, document availability of data and information for each segment, identify trends in water quality conditions and provide information to managers for priority setting. This comprehensive report is broken down into five parts into which all water segments within a state can be categorized. These categories are described in Table 3.

Table 3. USEPA Integrated Report listing categories

Category 1	All designated uses are supported, no use is threatened	
Category 2	Available data and /or information indicate that some but not all of the designated uses are supported	
Category 3	Insufficient available data and/or information to make a use support determination	
Category 4	Available data and/or information indicate that at least one designated use is not being supported or is threatened, but a TMDL is not needed. This category is further divided into sub categories a-c;	
	4a	Segments with completed TMDLs
	4b	Segments for which control measures other than a TMDL are expected to bring about WQS compliance
	4c	Segments demonstrating failure to meet WQS but not by a pollutant
Category 5	Available data and/or information indicate that at least one designated use is not being supported and a TMDL is needed – 303(d) List	

As guidance, Vermont is not required to follow the USEPA suggested listing format as outlined in the guidance document and has instead opted to present the state's Priority Waters List as described above. It should be noted however that VTDEC does submit Vermont's water quality status to EPA electronically which is compatible with the five category format. Table 4 compares the parts of the Priority Waters List to EPA's five categories.

Table 4. EPA Categories compared to Vermont's Priority Waters Lists

EPA Category	Vermont listing component	Notes
Category 1	NA	Waters in full support are not tracked on the Priority Waters List ¹
Category 2	NA	Waters where some but not all of the uses are supported are not tracked on the Priority Waters List
Category 3	NA	Unassessed waters are not tracked on the Priority Waters List ²
Category 4a	Part D	The waters in Part D are assessed as impaired. Waters coming back into compliance after a TMDL is complete will be removed from Part D.
Category 4b	Part B	
Category 4c	Parts E & F	
Category 5	Part A	EPA approved 303(d) list as well as proposed delistings

¹ Waterbodies or river miles in full support can be identified from Vermont's database through queries

² Waterbodies or river miles that are not assessed can be identified from Vermont's database through queries

Chapter Five. References

- Government Printing Office. 2001a. Federal Register 66:6, 1671-1674.
- Government Printing Office. 2001b. Federal Register 66:5, 1344-1359.
- USEPA. 2012. 2012 Recreational Water Quality Criteria. EPA-820-F-12-061. Washington, D.C.
- USEPA. 2005. Guidance for 2006 Assessment , Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act
- USEPA. 2003a. Guidance for 2004 Assessment, Listing and Reporting Requirements Pursuant to Sections 303d and 305b of the Clean Water Act. Washington, D.C.
- USEPA. 2001a. Guidelines for Preparation of the Comprehensive State Water Quality Assessments (305b Reports) and Electronic Updates. EPA-841-B-97-002A and EPA-841-B-97-002B. Washington, D.C.
- USEPA. 2001b. Water Quality Criteria for Methylmercury. EPA-823-R-01-001. Washington, D.C.
- USEPA. 2000a. Guidance: Use of Fish and Shellfish Advisories and Classifications in 303(d) and 305(b) Listing Decisions. EPA WQSP-00-03. Washington, D.C.
- USEPA. 2000b. Stressor Identification Guidance Manual. EPA-822-B-00-025. Washington, D.C.
- Vermont Agency of Natural Resources Department of Environmental Conservation Watershed Management Division. 2014. Vermont Water Quality Standards Environmental Protection Rule Chapter 29 (effective October 30, 2014). Montpelier, Vermont.
- Vermont Department of Environmental Conservation. 2000b. Interim Procedures for Determining the Biological Condition of Wadeable Streams. Waterbury, Vermont.
- Vermont Department of Environmental Conservation. 2002. 2002 Water Quality Assessment Section 305b Report. Waterbury, Vermont.
- Vermont Department of Environmental Conservation. 2003a. Final EPA-approved 2002 Part A–303d List of Waters. Waterbury, Vermont.
- Vermont Department of Environmental Conservation. 2003b. Stream Geomorphic Assessment Protocols. Waterbury, Vermont.
- Vermont Department of Environmental Conservation. 2003c. Development of Biocriteria for Vermont and New Hampshire Lakes. Criteria Development for Phytoplankton and Macroinvertebrate Assemblages for Three Lake Classes. Waterbury, Vermont.
- Vermont Department of Environmental Conservation. 2007. Development of Biocriteria for Vermont and New Hampshire Lakes Criteria Development for Macroinvertebrates for Three Lake Classes and Implementation Procedure for Biological Assessment of Vermont Lakes. Waterbury, Vermont.

Appendix A: Using Conductivity as a Surrogate for Chloride

Continuous Conductivity Datasets

Chloride is a unique parameter when it comes to measuring it in the aquatic environment. Not only can you measure it directly in the laboratory from grab samples, but specific conductivity has been shown to be a reliable surrogate for measuring it in the field. By using modern water quality probes and dataloggers, continuous estimates of chloride can be obtained for weeks or months at a time. Simple regression equations relate specific conductivity measurements to chloride concentrations and recent studies in the Chittenden County region of Vermont have successfully employed these techniques. The continuous datasets make it easier to make assessments relating the 3 aspects of the WQS: magnitude, duration and frequency, and are particularly useful in assessing the 4-day duration aspects of the chronic criterion.

Where adequate continuous conductivity datasets exist, they will be assessed based on the duration of exposure and the frequency of exceedance criteria as described below:

Acute Criterion Dataset

A continuous dataset applicable for the acute criterion means specific conductivity samples taken at least every 15 minutes for a duration that equals or exceeds the duration that the acute criteria (i.e. 1 hour). The arithmetic average chloride concentrations estimated from specific conductivity measurements, taken over the 1 hour, shall be compared to the acute criterion to determine compliance or noncompliance.

Chronic Criteria Dataset

A continuous dataset applicable for the chronic criterion means specific conductivity samples taken at least every hour for a duration that equals or exceeds the duration that the chronic criteria (i.e., 96 hours). The arithmetic, moving average of chloride concentrations, estimated from specific conductivity measurements, taken over the 96 hour period shall be compared to the chronic criterion to determine compliance or noncompliance.

For a continuous dataset to be considered complete and comparable to the criteria, samples must have been collected over a time period that encompass the exposure period that the criteria is based on (i.e., 1 hour for acute and 96 hours for chronic criteria).

Rolling averages are calculated for all possible blocks of 1 hour (acute criteria) or 96 hours (chronic criteria). The time blocks overlap. For example, the 1 hour average value is calculated when four specific conductivity measurements were made within any given hour at 15 minute increments and the 96 hour average value is calculated if 384 specific conductivity measurements are made over any given four day period.

For comparison of continuous datasets to the frequency component of the standard, the average of either the acute or chronic exceedences shall not exceed the frequency of exceedance (i.e. an average of no more than 1 exceedence every 3 years).

Specific Conductivity as a Chloride Surrogate

Specific conductivity can be used as a surrogate for chloride samples. When specific conductivity is used as a surrogate for chloride, it is necessary to collect at least 2 chloride samples within each time period that the specific conductivity to chloride relationship is to be used. These samples will be used to confirm that the

site fits the statewide specific conductivity to chloride relationship. If confirmation samples do not adequately fit the statewide relationship, a site-specific relationship can be developed (see discussion below).

Conductivity/Chloride Relationship

An ordinary least squared regression was fit to all chloride-specific conductivity data pairs collected in Vermont from 2003 to 2010, and again in 2013. A minimum chloride threshold of 30 mg/L was applied to these data. Chloride concentration observations below 30 mg/L are numerous, far below water quality criteria, and tend to bias the results of regression analyses; removing low chloride concentrations improves regression fit and model diagnostics. A total of 441 observations were used in the model.

The final regression equation has an adjusted r-squared value of 0.94 (Eqn. 1):

$$\text{Chloride (mg/L)} = -69.72 + 0.292 * \text{Specific Conductivity } (\mu\text{S}) \quad \text{Eqn. 1}$$

This r-squared value indicates that specific conductivity explains about 94% of the observed variation in chloride concentration.

The Division anticipates that this regression equation will be sufficient in most cases to accurately estimate chloride concentrations when site specific regressions are not available. However, where site specific data is sufficient, a site-specific regression may be preferred.

Criteria for Using the State-Wide Chloride Regression

Study Areas without a Site-Specific Chloride Regression

If the organization/researcher has not developed a site-specific chloride regression that is equal to or better than the WSMD state-wide chloride regression, the organization/researcher should use the WSMD state-wide chloride regression. The organization/researcher should follow the steps listed below to verify that the state-wide regression is acceptable for their study site.

1. The organization/researcher will collect at least 2 data pairs of chloride concentration and specific conductivity on water samples collected from the study area. If possible, the data pairs should be collected during different flow conditions and seasons.
2. If the data pairs consistently fall outside the 95th percentile prediction interval for the WSMD state-wide regression, then the organization/researcher should question whether the WSMD state-wide regression is appropriate for their study site. A figure depicting the WSMD state-wide regression line with 95% prediction intervals is provided below for reference.

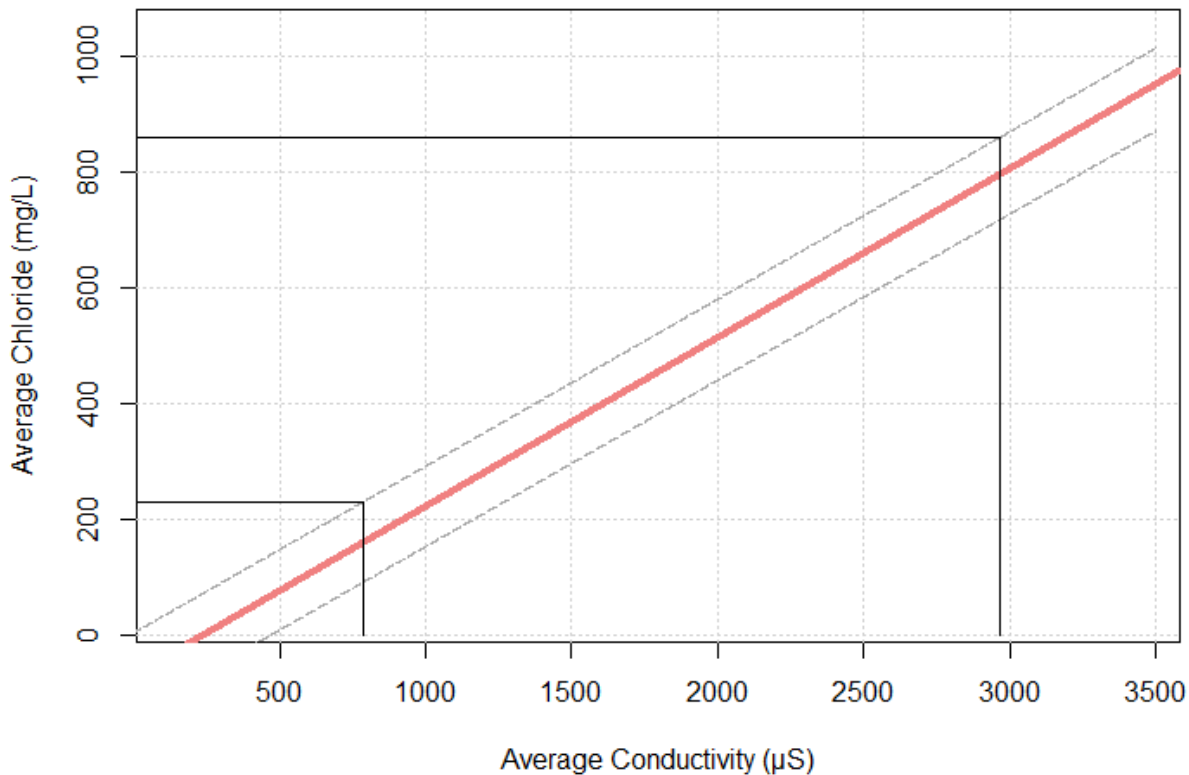


Figure A1. WSMD state-wide chloride-specific conductivity regression line with 95% confidence intervals. The points at which the 95% prediction interval exceeds the chronic (230 mg/L) and acute (860 mg/L) chloride concentrations are shown.

3. Because confidence and prediction intervals vary across the range of observed values, no single equation for these intervals can be provided. However, using the WSMD state-wide regression, the conductivity values associated with a 95% prediction interval above the relevant chloride criteria can be calculated; these values show the threshold at which an observed conductivity concentration is no longer 95% sure to be below the chloride criteria, based on the fitted model. These values are:

Table A1. Specific conductivity values whose 95% prediction interval exceed the chronic and acute chloride criteria, respectively.

Chloride (mg/L) Standard	Conductivity (µS)
Chronic, 230	784
Acute, 860	2966

For instance, we cannot be 95% confident that a conductivity value of 784 (µS) is below the chronic standard.

Study areas with Site-Specific Chloride Regressions

If the organization/researcher has developed a site-specific chloride regression that is equal to or better than the WSMD state-wide chloride regression, the organization/researcher should use the site-specific regression.

The following guidance should be used to determine if the site-specific regression is superior to the state-wide regression.

1. The chloride-specific conductivity data pairs should be representative of the study area in terms of seasons and flow conditions. In particular, the data pairs should have the following characteristics:

- If the organization/researcher collects specific conductivity data during the winter season (Nov-Mar), the data pairs should be collected during the winter season. If the organization collects specific conductivity data during the summer season (Jun-Sept), the data pairs should be collected during the summer season. If the organization collects specific conductivity data in both seasons, the data pairs should be collected from each season.
- Some of the data pairs should be collected during low flow conditions and some from high flow conditions in each season.
- Some of the data pairs should be for water samples with “high” conductivity readings relative to the maximum specific conductivity measured in the study area. The maximum conductivity in a calibration data pair should not be less than 75% of the maximum conductivity measured in the study area.

2. The site-specific regression should have a reasonable r-squared that will be evaluated by the WSMD on a case by case basis. As currently formulated, the state regression has an adjusted r-squared value of 0.94.

3. The site-specific regression should meet the four principal assumptions of linear and generalized linear regressions:

- The relationship between chloride and specific conductivity should be linear and additive.
- Model errors should be normally distributed.
- Model errors should exhibit statistical independence; for instance, error values should not be correlated by date, time, month, season, etc.
- Model errors should demonstrate constant variance (*homoscedasticity*) with regards to sample time and date, predicted chloride values, and specific conductivity values.

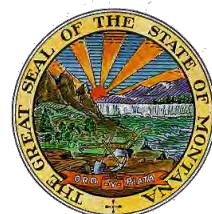


Assessment Methodology for Determining Wadeable Stream Impairment Due to Excess Nitrogen and Phosphorus Levels

DECEMBER 2011

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ACRONYMS

Acronym	Definition
ADB	Assessment database
AFDW	Ash Free Dry Weight
ARM	Administrative Rules of Montana
BACI	Before-After-Control-Impact
BACIP	Before After Control Impact Paired
BOD	Biochemical Oxygen Demand
BPJ	Best Professional Judgment
CFR	Clark Fork River
CV	Coefficient of Variation
DEQ	Department of Environmental Quality (Montana)
DO	Dissolved Oxygen
DPHHS	Department of Health and Human Services
EPA	Environmental Protection Agency (US)
HBI	Hilsenhoff Biotic Index
LOWESS	locally-weighted regression line
QAPP	Quality Assurance Project Plan
SAP	Sampling and Analysis Plan
SOD	sediment oxygen demand
SOP	Standard Operating Procedures
SRP	Soluble Reactive Phosphate
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
WQPB	Water Quality Planning Bureau (DEQ)

NITROGEN AND PHOSPHORUS IMPAIRMENT ASSESSMENT: METHOD SUMMARY

The following Method Summary should provide sufficient detail for an assessor to undertake an assessment of nitrogen and phosphorus impacts in a wadeable stream. *You will probably still need to refer to details provided later in the document.* Large rivers are not addressed by this methodology; a list of large rivers to which these methods do not apply is shown below in **Table S-1**.

Table S-1. Non-wadeable river segments within the state of Montana

River Name	Segment Description
Big Horn River	Yellowtail Dam to mouth
Clark Fork River	Bitterroot River to state-line
Flathead River	Origin to mouth
Kootenai River	Libby Dam to state-line
Madison River	Ennis Lake to mouth
Missouri River	Origin to state-line
South Fork Flathead River	Hungry Horse Dam to mouth
Yellowstone River	State-line to state-line

Part 1: Defining the assessment reach

1. Compliance determinations described in this document are carried out on an assessment reach. Here we define an assessment reach as: *a wadeable stream segment listed in the Assessment Data Base (ADB; (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2009) and updates), or a sub-segment of an ADB stream segment.* A sampling unit within an assessment reach is defined as: *a sample collected from the assessment reach that is largely independent of other samples collected within the assessment reach and collected during the time when the numeric nutrient criteria apply.* Please consider the following:
 - a. The aggregate of samples collected from an assessment reach should provide good overall representation of the assessment reach. Individual sites within the assessment reach that have known or suspected pollution problems should be sampled equitably along with sites where pollution problems are not suspected or are minimal or less pronounced. Do not just target the hotspots.
 - b. Given the guidelines in 1a above, the assessor will have to judge if further stratification of the stream reach (i.e., create two or more sub-reaches) is warranted. If, for example, a relatively un-impacted upstream reach of an assessment reach can be isolated and its condition is substantially different from other downstream parts of the assessment reach, sub-segmenting may likely be justified. As a rule of thumb, it is better to lump than split reaches to avoid excessive sub-segmentation of streams and the consequential administrative and sampling requirements.
 - c. Each sub-reach will have the same general data requirements (dataset minimums, tests, etc.) as the parent assessment reach would have had if it hadn't been divided.
 - d. Samples should be collected when the criteria apply, during the ecoregion-specific Growing Season (**Table S-2**). However, a ten day window (plus/minus) on the Growing Season start

and end dates is acceptable in order to accommodate year-specific conditions (e.g., an early-ending spring runoff). Samples collected outside the Growing Season may be useful for other purposes (e.g., isolating load sources), but should not to be used for compliance determination for the Growing Season.

Table S-2. Start and Ending Dates for Three Seasons (Winter, Runoff and Growing), by Level III Ecoregion

Ecoregion Name	Start of Winter	End of Winter	Start of Runoff	End of Runoff	Start of Growing Season	End of Growing Season
Canadian Rockies	Oct.1	April 14	April 15	June 30	July 1	Sept. 30
Northern Rockies	Oct.1	March 31	April 1	June 30	July 1	Sept. 30
Idaho Batholith	Oct.1	April 14	April 15	June 30	July 1	Sept. 30
Middle Rockies	Oct.1	April 14	April 15	June 30	July 1	Sept. 30
Northwestern Glaciated Plains	Oct.1	March 14	March 15	June 15	June 16	Sept. 30
Northwestern Great Plains	Oct.1	Feb. 29	March 1	June 30	July 1	Sept. 30
Wyoming Basin	Oct.1	April 14	April 15	June 30	July 1	Sept. 30

2. Samples from within an assessment reach may generally be considered independent of other samples from the assessment reach if they meet or if you do the following:
 - Sites (or very short reaches functionally equivalent to sites) should be located at least 1 stream mile apart.
 - Sites may be placed < 1 mile apart on an assessment reach **if** there is a flowing tributary confluencing with the reach between the two sites.
 - Along an assessment reach, try to sample sites moving from downstream to upstream to avoid potentially re-sampling the same stream water.
 - Land use changes and land form changes should be considered and can be used to help define (1) breaks between assessment reaches and/or (2) additional sampling sites within an assessment reach
 - Samples collected at the same site should be collected about 30 days apart. This does not apply to long-term or instantaneous measurement of dissolved oxygen.

Part 2: Assessment Methodology

The following are recommended to determine nitrogen and phosphorus impacts in wadeable streams.

For Mountainous and Transitional¹ Streams: Assessment is carried out as a level I, level II process. If the level I results are inconclusive, move to the 2nd level².

Level I:

- a. Collect, within the assessment reach, benthic algal Chl *a* and AFDW (Ash Free Dry Weight) from one or more sites³ (following DEQ SOPs, including approved low-chlorophyll visual

¹ See **Table 4-1** later in this document for the list of ecoregions (levels III and IV) where this methodology applies.

² Nothing precludes the assessor from collecting, in a single sampling season, all data needed to carry out a level II assessment. Cases may arise (e.g., land access issues) that may make this approach preferable.

³ Treat each Chl *a* sampling event as an independent evaluation of use support Do not average together results from different sites within the assessment reach If Chl *a* is measured more than once at the same site, treat each sampling event as unique (NOT as temporal repeat measures)

estimation methods) for a minimum of three sampling events. A minimum of twelve or thirteen⁴ independent nutrient samples should be collected within the same assessment reach. Use of diatom samples at level I are optional, but if the data exist ($n \geq 2$ samples), they must be used in the assessment. Disperse sampling effort across sites as much as possible. The nutrient data are evaluated using the “Exact Binomial Test” and the “One-Sample Student’s t-test for the Mean” which are housed in one of two Excel spreadsheets. If the assessment reach is a new, un-listed segment, use “MT-NoncomplianceTool.xls”. If the assessment reach is already listed for a nutrient, use MT-ComplianceTool.xls”. However, if a stream is currently listed for nitrogen but not for phosphorus, use the “MT-NoncomplianceTool.xls” to assess the phosphorus data.

- b. In both spreadsheets, for either test, set alpha to 0.25 (25%) and the critical exceedance rate (p) to 0.2 (20%) in cells B5, B6. In the Binomial test the effect size (p2; gray zone) should be 0.15 (15%) and is set as a function of the exceedance rate. So, in “MT-NoncomplianceTool.xls” this means p2 should be set to 0.35 (cell B7), and in “MT-ComplianceTool.xls” p2 should be set to 0.05 (cell B7). If in the future DEQ decides that a lower exceedance rate (e.g., 10%) is needed, the gray zone will need to be adjusted accordingly.
- c. Compliance with the nutrient criteria is determined via decision rules, which consider the Chl *a* and AFDW averages calculated for each sampling event, the results from the two nutrient statistical tests, and diatom metric results (if available). Go to the first tab of the Excel spreadsheet named “NtrntAssessFramework.xlsx”. If the result is clear (assessment reach is or is not nutrient impaired), you are finished. If not, follow the instructions in the spreadsheet for level II assessment.
- d. Most often, you will be assessing both N and P in an assessment reach. Consider the N and P results side-by-side; does it appear that one nutrient or the other is giving a clear signal (e.g., Binomial and T-test are both FAIL for Total Phosphorus (TP), but both PASS for Total Nitrogen (TN)? In this case, the best nutrient to list would be TP. Mixed results for both nutrients often will require a move to a level II assessment, and may lead to listing both N and P.

Level II:

- a. Moving to level II often (not always) involves additional data collection, including more nutrient samples and benthic algal Chl *a*/AFDW samples. Level II data include both diatom and macroinvertebrate samples (at least two sampling events for each). **The exception to this is the Middle Rockies ecoregion, for which there are no validated diatom increaser metrics. In this ecoregion collect at least three macroinvertebrate samples.** As for level I, each sampling event for diatoms should be considered on its own merits (do not average results across sites, or across time at a site). In contrast, macroinvertebrate samples collected across time at a site should be averaged together; however, keep and assess data from different sites separate. When your dataset is ready, first pass data again through the

⁴ Twelve independent nutrient samples for new, unlisted streams, and thirteen for streams already listed for nutrients on the 303(d) list. A nutrient sample is a type of nutrient (e.g., TP or TN) Sample minimums apply to *each* nutrient type. Smaller sample sizes may be justified; see **Section 3.2.2.1**, this document

Level I process using NtrntAssessFramework.xlsx. If results are clear, you are finished; if not, go to the 2nd tab.

- b. Some data combinations at level II (2nd tab of the spreadsheet) will still lead to an unclear result. If this occurs, consult with your manager about how to proceed.

*For Warm Water Plains Streams*⁵: Assessment is carried out as a level I, level II process. If the level I results are inconclusive, move to the 2nd level².

Level I:

- a. Determine, for at least 3 sampling events, the dissolved oxygen (DO) delta (i.e., the daily DO maximum minus the daily DO minimum). The daily minimum can be measured pre-dawn to 8:00 am, while the daily maximum usually occurs between 2:30 pm to 5:00 pm. Alternatively, collect a long-term DO dataset by deploying a YSI 6600 (or similar instrument) in at least one site; measure DO for at least 1 full day, with a 15-min time step. Even if you collect DO data with a deployed instrument, you still need a total of three sampling events (three days). **However, DO delta values need not be collected 30 days apart.** Also, collect within the assessment reach at least two diatom samples and a minimum of twelve or thirteen⁴ nutrient samples. Disperse sampling effort across sites as much as possible. The nutrient data are evaluated using the tests “Exact Binomial Test” and the “One-Sample Student’s t-test for the Mean” found in one of two Excel spreadsheets. If the assessment reach is a new, un-listed segment, use “MT’NoncomplianceTool.xls”. If the assessment reach is already listed for a nutrient, use MT-ComplianceTool.xls”. However, if a stream is currently listed for nitrogen but not for phosphorus, use the “MT-NoncomplianceTool.xls” to assess the phosphorus data.
- b. See 1b above (in the Mountainous and transitional streams section) for instructions on setting test conditions in each Excel spreadsheet.
- c. Compliance with the nutrient criteria is determined via decision rules, which consider together the results from the diatom metrics, the DO delta values, and the two statistical tests for nutrients. Go to the 3rd tab (plains level I) of the Excel spreadsheet “NtrntAssessFramework.xlsx”. Long-term DO datasets require special consideration; see **Section 3.2.4**, scenario 2, and **Section 5.0** for details. If the result is clear (assessment reach is or is not nutrient impaired), you are finished. If not, follow the instructions in the spreadsheet for level II assessment.
- d. Most often, you will be assessing both N and P in an assessment reach. Consider the N and P results side-by-side; does it appear that one nutrient or the other is giving a clear signal (e.g., Binomial and T-test are both FAIL for TN, but both PASS for TP)? In this case, the best nutrient to list would be TN. Mixed results for both nutrients often will require a move to a level II assessment, and may lead to listing both N and P.

⁵ See **Table 5-1** later in this document for the list of ecoregions where this methodology applies.

Level II:

- a. A level II assessment will often require additional data collection, including more nutrient and DO data, and (in some cases) biochemical oxygen demand (BOD₅) data. As for level I, each DO delta value should be considered on its own merits (do not average results across sites or across time), as is also the case for BOD₅ samples. When the data are ready, first pass the now-larger dataset back through the Level I assessment process. If results are clear, you are finished; if not, go to the appropriate scenario in the 4th tab (plains level II).
- b. Some level II data combinations still lead to an unclear result. If this occurs, consult with your manager about how to proceed.

1.0 INTRODUCTION

The purpose of this document is to describe a framework for making decisions. Specifically, it defines a process by which one can determine if a wadeable stream is or is not impaired by nitrogen and phosphorus pollution (i.e., excess nutrients). The document covers a number of subjects including how to determine an appropriate sampling frame, which parameters are most useful for assessing nitrogen and phosphorus problems, how many samples are needed, how data are to be treated statistically, and how disparate data types are to be assembled in a final decision matrix.

In this document we have attempted to organize the information in a manner such that the users can locate what they need quickly, and then read further for details only if they want to. The “why” discussions (i.e., why did we select a particular assessment parameter, why did we pick the impact threshold, etc.) are found in the appendices. We did this because we know that stream assessments are time-consuming undertakings, and therefore users will want to access the critical information easily.

1.1 SCOPE OF THE ASSESSMENT METHODOLOGY

Different assessment methods are recommended for different regions of the state (**Figure 1-1**). The assessment parameters that have been recommended for each region are the ones we believe are the most accurate and sensitive for determining nitrogen and phosphorus impacts for wadeable streams in those areas. For example, we recommend measuring dissolved oxygen in eastern Montana plains streams, but we have not recommended this approach for western Montana salmonid streams. This should not be construed to mean that DO concentrations in salmonid streams are never affected by nitrogen and phosphorus pollution, or that in any way this recommendation overrides existing DO standards for those state waters. Rather, we believe that in western Montana salmonid streams there are assessment tools other than DO that are more sensitive and will more readily detect nitrogen and phosphorous problems.

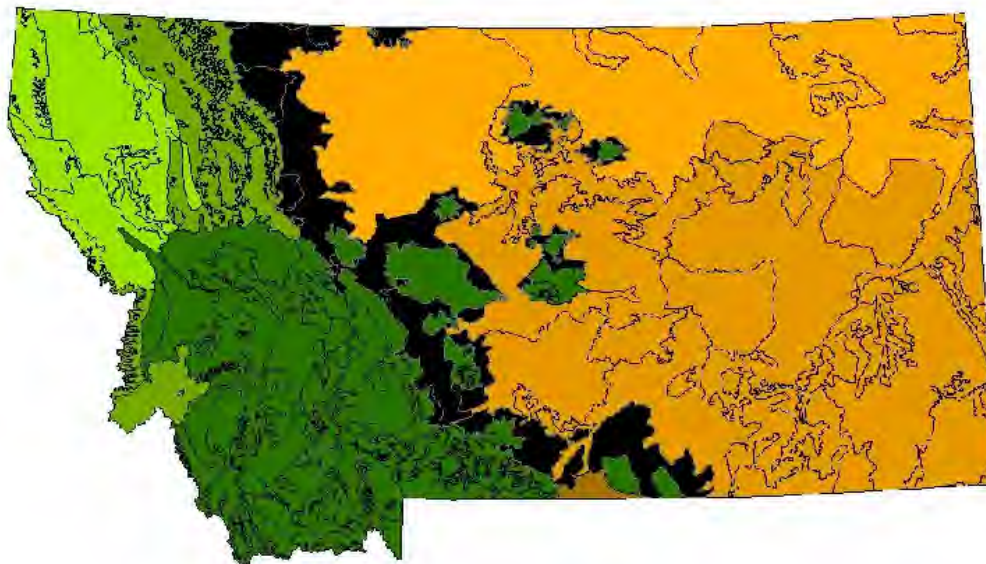


Figure 1-1. Map Showing Different Regions in which Different Assessment Methodologies Apply.
The areas shown in shades of green and black comprise the mountain and transitional streams region. The areas shown in shades of brown comprise the eastern Montana plains region.

As mentioned above, methods in this document apply to wadeable streams. A DEQ workgroup spent considerable time working to define the break between wadeable streams and rivers and non-wadeable rivers, the results of which are presented in Flynn and Suplee (2010). The waterbodies that are not considered wadeable are provided below in **Table 1-1**.

Table 1-1. Non-wadeable river segments within the state of Montana

River Name	Segment Description
Big Horn River	Yellowtail Dam to mouth
Clark Fork River	Bitterroot River to state-line
Flathead River	Origin to mouth
Kootenai River	Libby Dam to state-line
Madison River	Ennis Lake to mouth
Missouri River	Origin to state-line
South Fork Flathead River	Hungry Horse Dam to mouth
Yellowstone River	State-line to state-line

2.0 RECOMMENDATIONS FOR ISOLATING A STREAM REACH FOR ASSESSMENT (THE SAMPLE FRAME)

Identifying and isolating an appropriate stream reach (sample frame) is the first required task. The following definitions are presented:

- **Sample Frame:** A wadeable⁶ stream segment listed in the Assessment Data Base (ADB) (DEQ 2009, and updates) OR a sub-segment of an ADB stream segment. A segment such as this is referred to in this document as an “assessment reach”.
- **Population:** All the water flowing through the assessment reach during the time period when the numeric nutrient criteria apply, and the surface area of the stream bottom over which the water flows.
- **Sampling Unit:** A sample collected from the assessment reach that is largely independent of other samples collected within the assessment reach and collected during the time when the numeric nutrient criteria apply.

A sampling frame must be representative of the population and, in stream assessment, this demands good judgment in the particular subject matter being studied. **Sections A.1 and A.2 of Appendix A** of this document, which is an updated and shortened version of an earlier Appendix H (Varghese and Cleland, 2008), contain a discussion on approaches to identifying assessment reaches.

The key idea presented in **Appendix A** is that each assessment reach that is assessed should be sufficiently homogenous that data collected from sites along the reach can be considered to represent the entire reach. To determine compliance with numeric nutrient criteria using statistical methods, it is important that (1) pollution sources generally be evenly dispersed along the reach, and (2) each sample is independent of the others. Following up on this idea, if an assessment reach appears to need further subdivision (e.g., into a reach above and a reach below a pollution point source), then each new assessment reach should generally be sampled with the same intensity (i.e., minimum sample size) as the parent reach would have been if it had not been subdivided. This will assure that the statistical rigor associated with specified sample-size minima (discussed below) is maintained. At the same time, as a general rule, it is better to lump than split to avoid unnecessary sampling and administrative work.

The need to create reasonably uniform assessment reaches is inherently in conflict with the need to “lump”, the purpose of which is to keep stream reaches from being excessively subdivided (and all the additional work that entails). Judgment is needed on the part of the assessor to balance these two opposing factors and come up with an optimal sampling strategy for any given stream.

This process should be compatible with a randomized study of stream reaches as well as targeted, risk-assessment based approaches; again, the key point is that each assessment reach is sufficiently defined.

3.0 ASSEMBLING THE NUTRIENT ASSESSMENT DATA INTO A DECISION FRAMEWORK

Section 2.0 above discussed approaches used to identify appropriate assessment reaches. This section discusses how data that will have been collected from the assessment reach are to be assembled into a decision-making framework. The parameters and methods apply to wadeable streams. Non-wadeable waterbodies were listed back in **Table 1-1**.

⁶ Wadeable streams are perennial as well as intermittent (ARM 17.30.602 [15]) streams in which large portions of the channel are wadeable during baseflow conditions. For the list of waterbody segments not considered wadeable (i.e., the large rivers), see **Table 1-1** above. Derivation of the **Table 1-1** list is found in Flynn and Suplee (2010).

3.1 OVERVIEW OF USEFUL PARAMETERS FOR CARRYING OUT NUTRIENT IMPAIRMENT ASSESSMENTS

Among the vast array of parameters that can be measured in a stream, we narrowed the list to those we believe are the best, readily-measured indicators of stream nitrogen and phosphorus enrichment (**Table 3-1**). Many of these parameters are discussed in Suplee *et al.* (2008), and are also discussed in detail in the appendices of this document.

Table 3-1. Parameters in Streams that are Considered Useful in Assessing Nutrient Enrichment

Parameter	How collected	Linkage to nutrient enrichment	Primary or secondary indicator*
Total nitrogen	Water sample	Total instream concentrations are indicative of the level of nutrients that are ultimately biologically available for autotrophic or heterotrophic uptake.	Primary
Total phosphorus	Water sample	Total instream concentrations are indicative of the level of nutrients that are ultimately biologically available for autotrophic or heterotrophic uptake.	Primary
Benthic algal biomass	Benthic samplings of stream bottom	Nutrients stimulate benthic algal growth in wadeable streams Benthic algal growth can develop to nuisance levels; nuisance algae level is known. Excess algal growth affects on DO have been documented.	Primary
Dissolved oxygen <i>delta</i> (daily max value minus the daily min value)	<u>Instantaneous</u> : By hand-held instrument, at dawn and in the late pm. <u>Continuous monitoring</u> : by deployed instrument	Nutrient enrichment stimulates autotrophic primary productivity and heterotrophic decomposition of organic material. Both of these in turn affect dissolved oxygen patterns in streams.	Primary
Diatom biometric (nutrient increaser taxa metric)	Benthic sampling of stream bottom	As primary producers, diatoms can be directly stimulated by increased availability of N and P. Diatom population structure has been found to vary in predictable ways with increasing nutrient enrichment.	Primary and Secondary
Macroinvertebrate biometric (Hilsenhoff Biotic Index, or HBI)	Kicknet sampling of stream bottom	A large number of macroinvertebrate taxa have been assigned a numeric value which represents each organism's tolerance to low dissolved oxygen/organic pollution. Resulting metric (HBI) found to significantly correlate to total nutrient concentrations in Montana streams.	Secondary
Biochemical oxygen demand (BOD ₅)	Water sample; must be at laboratory within 48 hrs	High BOD can indicate presence of large quantities of dissolved and suspended organic matter, whose decomposition can produce a large DO demand. Can help determine if DO sags are caused by high primary productivity, high BOD, or both.	Secondary

Table 3-1. Parameters in Streams that are Considered Useful in Assessing Nutrient Enrichment

Parameter	How collected	Linkage to nutrient enrichment	Primary or secondary indicator*
Stream macrophyte species	By hand; field identification	Observed shift in dominance to a single macrophyte species in highly enriched prairie streams; loss of <i>Chara</i> .	Secondary

*Primary means the parameters is considered to be a very good indicator of nutrient enrichment. Secondary mean the parameter is considered a good indicator of nutrient enrichment, or helpful in identifying other factors affecting DO (e.g., BOD).

Note that **Table 3-1** contains physical and biological measurements. We support the long-held view in the WQPB that stream assessment is best carried out by looking at both data types together. The famous water-pollution biologist H.B Hynes said it best: “When the chemist and the biologist both work on the assessment of pollution they can discover much more together than either can alone” (Hynes, 1966).

The parameters in **Table 3-1** need to be arranged in a decision making framework in order to produce consistent decision outcomes (i.e., stream *is* impaired by nutrients, stream *is not* impaired by nutrients). **Figure 3-1** below outlines the process we recommend for this purpose.

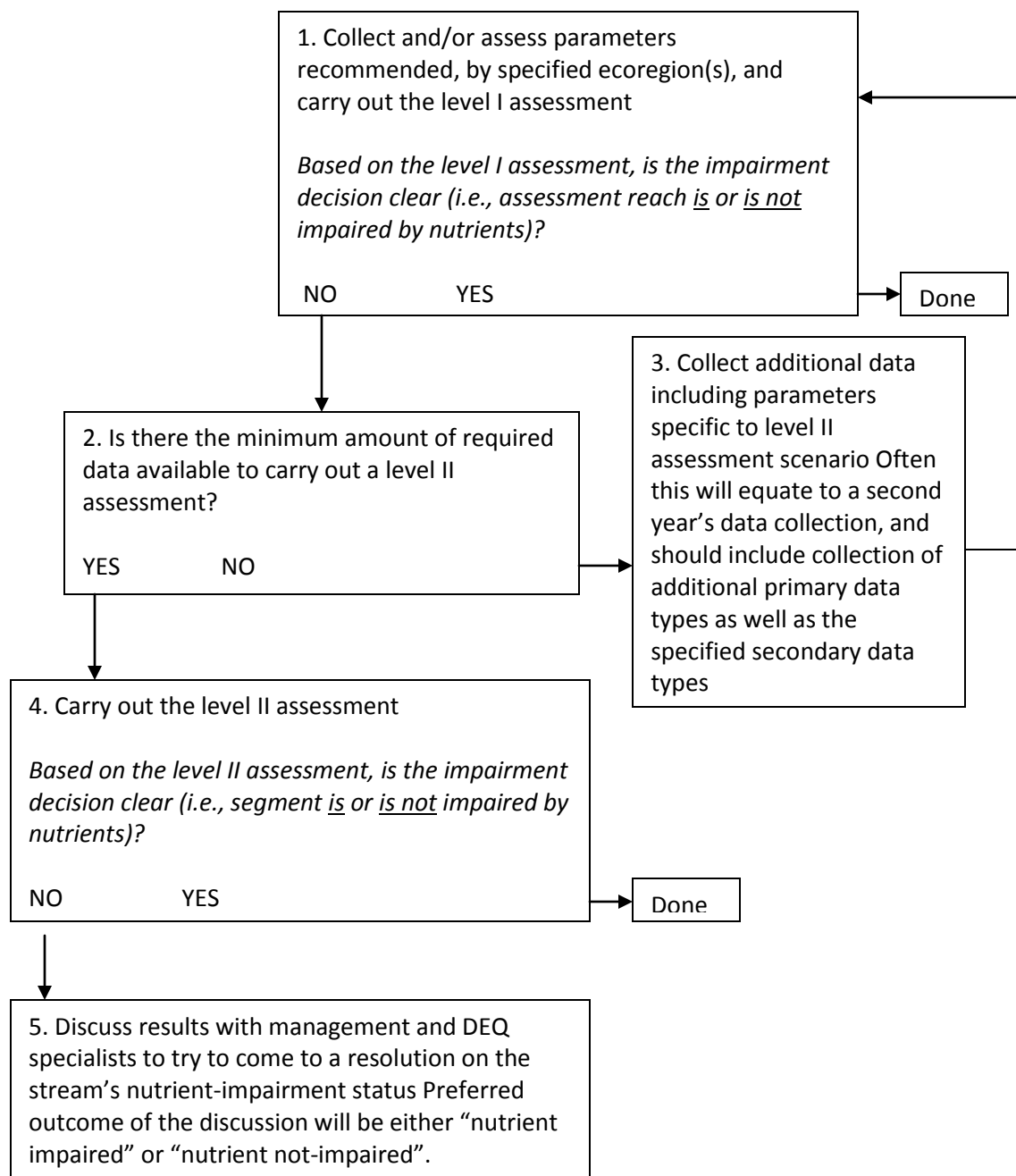


Figure 3-1. Flow-path for decision making using data parameters in Table 3-1.

If the level I assessment leads to an unclear decision, the assessor should then use the data (primary and secondary, if data sufficiency met) to carry out the level II assessment⁷. If a level I assessment is inconclusive and leads to a 2nd year of data collection, always pass the now-larger dataset back through the level I assessment matrix first. It may result that the conclusion is now clear, without having to go to level II. **NOTE:** Nothing in the approach shown in **Figure 3-1** precludes an assessor from collecting,

⁷The approach shown in **Figure 3-1** closely parallels the decision framework of EPA's CALM guidance (U.S. Environmental Protection Agency, 2002); see **Figure 3.2**, page 3-10 of that document.

in a single field season, all data needed to complete a level I and a level II assessment. Situations may arise (e.g., land access issues) where this approach is preferable.

As can be seen, one notable aspect of the approach in **Figure 3-1** is that the data we have labeled “secondary” (**Table 3-1**) are brought into the decision framework only after the primary data have lead to an unclear conclusion. In effect, secondary data are being held to the side until the primary data have been played out to their fullest. The approach attempts to keep data combination scenarios to a minimum and decision making as simple as is reasonable (Occam’s razor; “plurality should not be posited without necessity”)⁸.

The different combinations of results that can occur have been assembled in an Excel spreadsheet (**NtrntAssessFramework.xlsx**). In the spreadsheet, the user identifies the unique combination of results from their assessment reach, and then derives a conclusion. For each combination of results, the spreadsheet provides an outcome (i.e., nutrient impaired, not-nutrient impaired, unclear), and an explanation as to what is likely going on in the stream’s ecology. **Different parameter sets are used in different geographic regions, therefore the user must use the tabs for the region applicable to their stream.** Regional tabs are further subdivided to correspond to a level I or level II assessment, per the approach shown in **Figure 3-1**. As an example, three result combinations for the mountain and transitional region are given in **Table 3-2**.

Table 3-2. Three combinations of results, and the conclusions that can be drawn from them, using the parameters listed in Table 3-1.

All three examples apply to streams of the mountain and transitional region of the state, and are from a level I assessment.

Scenario	Nutrient Binomial Test	Nutrient T-test	Benthic Algae	Diatom Increaser Taxa-Probability of Impairment (OPTIONAL)*	Resulting Decision	Further Sampling?
1	PASS	PASS	≤120 mg Chl <i>a</i> /m ² or ≤35 g AFDW/m ²	<51%	Waterbody is <u>not</u> nutrient impaired. All indications show that the stream is in compliance.	No

⁸ We did this for two reasons. First, we believe that in most cases some types of data are inherently better for nutrient-enrichment assessment than others, and if the decision can be made using those data alone, the assessment will be simpler and less expensive. Second, it reduces the total number of data-combination outcomes and, in turn, the number of scenario-by-scenario conclusions about impairment that have to be made. To illustrate, for any given data type for which there is a dichotomous outcome (i.e., result is above or below some threshold), the number of possible permutations is 2 raised to the number of data types. Three data types result in $(2^3) = 8$ possible data-combinations, and one must consider what each unique combination of results is saying about nutrient impairment. Five data types considered together already results in 32 unique combinations, and so on. If not all of the additional data are as useful as the previous, it becomes questionable whether the additional work, cost, and complexity are warranted.

Table 3-2. Three combinations of results, and the conclusions that can be drawn from them, using the parameters listed in Table 3-1.

All three examples apply to streams of the mountain and transitional region of the state, and are from a level I assessment.

Scenario	Nutrient Binomial Test	Nutrient T-test	Benthic Algae	Diatom Increaser Taxa-Probability of Impairment (OPTIONAL)*	Resulting Decision	Further Sampling?
12	PASS	FAIL	>120 mg Chl <i>a</i> /m ² or >35 g AFDW/m ²	>51%	Waterbody <u>is</u> nutrient impaired. Non-compliance with the T-test suggests that pulsed nutrient loads are allowing high algae biomass to be maintained via luxury uptake. Diatoms confirm enrichment finding.	No
16	FAIL	FAIL	>120 mg Chl <i>a</i> /m ² or >35 g AFDW/m ²	>51%	Waterbody <u>is</u> nutrient impaired. All indicators show that the stream is not in compliance.	No

*However, if the data minima are available for diatom metric category, they must be used in the decision framework

Subsequent sections will provide detail on which assessment parameters apply where, which statistical tools are to be applied to which parameters, etc. The important point to note here is that the combinations of results you will encounter have been accounted for in the spreadsheet tool (**NtrntAssessFramework.xlsx**).

Returning to **Figure 3-1**, the “Discuss results with management and DEQ specialists” outcome occurs when the level II assessment has still not resulted in a clear conclusion. This resolution step was suggested by Mark Bostrom (DEQ Bureau Chief) as a way to come to a conclusion without ending up in an endless do-loop. Details of this process remain to be worked out; a potentially useful framework for carrying out the determination has been developed by EPA (Cormier, et al., 2000; Cormier and Suter, II, 2008).

3.2 DETAILS ON THE USE OF NITROGEN AND PHOSPHORUS CONCENTRATION DATA, AND OTHER MEASURED PARAMETERS, TO SUPPORT NUTRIENT-IMPAIRMENT ASSESSMENTS

As noted above, different groups of parameters best apply to particular regions of the state. The applicable list of parameters, their impact thresholds, and the delineation of the regions are provided in **Section 4.0** (mountain and transitional streams) and **Section 5.0** (plains streams). In order to maintain temporal independence to the best degree possible, samples collected sequential at a site should be collected about **30 days** after the previous sampling. (There are exceptions to this; see individual parameter list in **Section 3.2.2** below.) Spatial independence of sites within an assessment reach can generally be established by following these guidelines:

- Sites (or short reaches equivalent to sites) should be located a minimum of 1 stream mile apart.

- Sites may be placed < 1 mile apart along the assessment reach if there is a flowing tributary confluencing with the segment between the two sites.
- Try to collect water samples starting at the downstream end of the assessment reach moving upstream, to avoid re-sampling the same water.
- Land use changes and land form changes should be considered and can be used to help define additional sampling sites within an assessment reach.

See **Section A.3** in **Appendix A** for the derivation of these guidelines.

Numeric nutrient criteria apply during summer baseflow⁹, also referred to as the growing season. Start and end dates for the growing season vary by ecoregion (Suplee, et al., 2008); see **Table 3-3** below. These dates should be adhered to for collection of the other parameters in **Table 3-1** as well. However, a ten day window (plus/minus) on the Growing Season start and end dates is acceptable, in order to accommodate year-specific conditions (e.g., an early-ending spring runoff). The assessor should use their best professional judgment when deciding if early or later sampling is warranted.

Table 3-3. Start and Ending Dates for Three Seasons (Winter, Runoff and Growing), by Level III Ecoregion

Ecoregion Name	Start of Winter	End of Winter	Start of Runoff	End of Runoff	Start of Growing Season	End of Growing Season
Canadian Rockies	Oct.1	April 14	April 15	June 30	July 1	Sept. 30
Northern Rockies	Oct.1	March 31	April 1	June 30	July 1	Sept. 30
Idaho Batholith	Oct.1	April 14	April 15	June 30	July 1	Sept. 30
Middle Rockies	Oct.1	April 14	April 15	June 30	July 1	Sept. 30
Northwestern Glaciated Plains	Oct.1	March 14	March 15	June 15	June 16	Sept. 30
Northwestern Great Plains	Oct.1	Feb. 29	March 1	June 30	July 1	Sept. 30
Wyoming Basin	Oct.1	April 14	April 15	June 30	July 1	Sept. 30

3.2.1. Nitrogen and Phosphorus Data

The nitrogen and phosphorus criteria are not presented in this document. Readers should refer to Suplee et al. (2008) and its addendums to locate the nutrient concentration values. DEQ anticipates that the nutrient criteria will be adopted by the Board of Environmental Review. After adoption they will be referred to as “base numeric nutrient criteria”, and will be housed in a new DEQ circular (DEQ-12). Please use the most updated versions of the criteria in all assessments. Check with Standards on status.

Nutrient (TN, TP) concentration data from an assessment reach are to be assessed collectively, i.e., all nutrient data collected along the reach are to be assessed together, using statistical tests. We recommend two statistical testing procedures to evaluate the nutrient dataset; the Exact Binomial Test and the One-Sample Student’s T-test for the Mean. The rationale for using two statistical tests is in **Appendix A**. The tests are in two Excel spreadsheets and their use is described below.

To use the statistical tests, do the following:

⁹ Lakes generally require year-round nitrogen and phosphorus criteria if they are to be protected from cultural eutrophication. This may in turn affect the time-of-application of nutrient standards in the near-field tributaries of those lakes.

- For new, un-listed stream segments, use the Excel spreadsheet tool named “MT-NoncomplianceTool.xls”.
- For already-listed stream segments, use the Excel spreadsheet tool named “MT-ComplianceTool.xls”
- In both tools, for either test, set alpha to 0.25 (25%)¹⁰. For the Binomial set the critical exceedance rate to 0.2 (20%) in cell B6. The effect size (gray zone) should be 0.15 (15%) and is set as a function of the exceedance rate. So, in the “MT-NoncomplianceTool.xls” this means p2 should be set to 0.35 (i.e., enter 0.35 into cell B7), and in “MT-ComplianceTool.xls” p2 should be set to 0.05 (enter 0.05 in cell B7).

Both tests (Binomial, T-test) will produce a result (PASS, FAIL). For the Binomial, you need to compare the allowable number of exceedances shown by the test (“es”, found in column D) to the actual number of exceedances manifested by your dataset. For the T-test, you will need to enter the dataset into the spreadsheet along with the criterion concentration against which the data are being compared. If the assessment reach complies with a test, the result is PASS; if the assessment reach does not comply with a test, the result is FAIL.

Note: If a non 303(d)-listed nutrient species is the same element as a listed one (e.g., stream is listed for nitrate, but you are also assessing TN, and TN is not currently listed), use the “MT-ComplianceTool.xls” for the non-listed nutrient species as well.

3.2.1.1 Minimum Sample Size for Nitrogen and Phosphorus Data

In the vast majority of cases the assessor will be making the nutrient-impairment decision with a fairly small nutrient-concentration dataset (probably < 13 samples). Statistics derived from small datasets such as these are subject to a fair amount of uncertainty. For example, outcomes from the Binomial Test (compliant, non-compliant) will, for nutrient sample sizes around 13, have confidence levels of about 75% (i.e., alpha and beta error of about 25% each).

For assessment reaches, the target number of nutrient samples is 12 (new, un-listed stream segments) or 13 (already-listed stream segments). The rationale for these sample sizes is presented in **Appendix A**.

HOWEVER: Cases exist where a dataset smaller than 12 or 13 will provide a sufficiently clear result that further nutrient sampling is not warranted. At about 6 samples or less, beta error in the Binomial test can become unacceptably high (> 65%) and increasingly worse with smaller *n*. At 7-8 samples, however, there are cases where a certain number of exceedances would be extremely unlikely unless the stream’s true exceedance rate was much in excess of 20%. Therefore, for sample sizes of 7, ≥ 4 exceedances can be considered FAIL for the Binomial test. If <4 exceedances are found, sampling should be resumed until the minimum of 12 or 13 is achieved. The T-test can also be used with 7 samples but its power is lower at this sample size. Please see the bullets in **Appendix A, Section A.5**.

Also, circumstances may arise where nutrient sampling that is planned over two field seasons may lead to a reduction in the necessary number of samples. For example, if at the end of year one ten (10) TN and TP samples have been collected from an assessment reach on an unlisted stream, and the number of exceedances in each dataset is one (1), it would not be necessary to collect the additional two samples

¹⁰ Alpha, exceedance rate, and the gray zone can be changed via the input cells in the upper left hand corner of the spreadsheet.

(to achieve 12) the following year. This is because even if both of the subsequent samples were above the criteria, the decision outcome (assessment reach “attains”) would not be altered. Assessors should consider these types of situations at the end of each field season in order to best optimize work and cost.

Important Caveat: When the nutrient-concentration dataset is large (as defined below), the nutrient impairment decision should be made using nutrient concentrations alone.

- Large nutrient dataset for already-listed segments: 90 samples in the assessment reach
- Large nutrient dataset for unlisted segments: 50 samples in the assessment reach.

The large sample sizes were determined using the Binomial distribution with an alpha of 0.05 (95% confidence level) and a balance between alpha and beta error (i.e., beta is also about 0.05).

If the large sample sizes listed above are available, the assessor should generally forgo the use of parameters other than total nitrogen and phosphorus (i.e., those in **Table 3-1**) in nutrient-assessment decision making. Nutrient concentrations alone can be used to assess standards compliance, via the Binomial test only.

3.2.2 Minimum Sample Sizes for Other Parameters

The remaining parameters in **Table 3-1** (with the exception of BOD₅; more on it below) are effect variables, i.e. they are affected by changes in nutrient concentrations. Sample size requirements for each parameter are summarized below. Each result, from a sampling event and for a parameter, should normally be considered on its own merits when using the decision spreadsheet (NtrntAssessFramework.xls) and completing the assessment. Exceptions to this exist; see below. The parameters applicable to specific regions (mountain and transitional streams vs. plains streams) and the impact thresholds associated with those parameters are given **Section 4.0** and **Section 5.0**. **Important Note:** Within their region of application, parameters shown below are required in order to carry out a level I assessment (see Figure 3-1). If a parameter is only required for a level II assessment, this will be indicated.

Benthic Algal Biomass Samples (Chl *a* and AFDW): At least three (3) sampling events for benthic algal biomass are to be carried out in the assessment reach. These may include approved visual estimation methods. If more than one site is established in the assessment reach, disperse sampling effort across the different sites. Otherwise, assure that about 30 days have passed before sampling again at the same site.

Diatom Samples (Nutrient Increaser Taxa Metric): At least two (2) diatom sampling events are to be carried out in the assessment reach. If more than one site is established in the assessment reach, disperse sampling effort across the different sites. Otherwise, assure that about 30 days have passed before sampling again at the same site. **Note:** Diatom samples are required at level I in the plains, but are only required for a **level II** assessment in the **mountain and transitional region**. However, since there is no validated diatom increaser metrics for the Middle Rockies ecoregion, they are not required collection there.

Macroinvertebrate Samples (HBI Metric): At least two (2) macroinvertebrate sampling events are to be carried out in the assessment reach, unless the site is in the Middle Rockies ecoregion, in which case at least three (3) sampling events are to be carried out. If more than one site is established in the assessment reach, disperse sampling effort across the different sites. **If only one site is present in the assessment reach, or if you decide to collect across-time samples at several sites,** collect the across-time samples at the site(s) approximately 30 days apart. The across-time HBI scores from a site should then be averaged prior to comparison to the threshold. If you only have one site, you will only have one HBI value for the assessment reach to compare to the threshold. **Note:** Macroinvertebrate samples are only required for a **level II** assessment, and only in the **mountain and transitional region**.

Sampling to Determine Dissolved Oxygen Delta: At least three (3) DO sampling events (i.e., days) are to be carried out in the assessment reach. If more than one site is established in the assessment reach, disperse sampling effort across the different sites. **DO deltas fluctuate rapidly, and therefore you do not need to wait 30 days to collect subsequent DO data at a site.** For example, collection at a site over 3 contiguous days is acceptable. The more DO deltas that can be collected in the assessment reach, the better.

BOD₅: At least three (3) BOD sampling events are to be carried out in the assessment reach. If more than one site is established in the assessment reach, disperse sampling effort across the different sites. Samples for the standard 5-day biochemical oxygen demand (BOD₅) test are similar to nutrient samples, in that they are a stream-water measurement that can change rapidly, and BOD's affect on DO varies according to other factors (e.g., wind mixing). **Note:** BOD₅ samples are only required for a **level II** assessment, and only in the **plains region**.

Observation Data for Macrophytes and Benthic Algae: The Fish Cover/Other form, i.e. the component of the form pertaining to macrophytes and benthic algal growth, is to be filled out in accompaniment with each benthic algal biomass and/or diatom sampling event. It should also be filled out at each site in the assessment reach at least once each summer. If across a summer growth conditions have notably changed at the site, fill it out again.

3.2.3 Determine the Nutrient Most Likely to be Harming Use(s)

Normally both N and P, and potentially different species of N (e.g., nitrate, TN), will be simultaneously evaluated within an assessment reach. Cases will arise where the harm-to-use signal from one element or the other is clearly stronger, which will help streamline the assessment determination and subsequent work (e.g., TMDL development). An example is provided below.

Table 3-4. Simultaneous Review of Multiple Nutrients and Effect Variables

Assessment Reach	Nutrient	n	Binomial	T-test	Diatom Increaser Taxa	Benthic Chl <i>a</i>
Fred Cr reach 1	NO ₃ +NO ₂	14	PASS	PASS	Exceeds criteria	Exceeds criteria
Fred Cr reach 1	TN	14	PASS	PASS	Exceeds criteria	Exceeds criteria
Fred Cr reach 1	TP	14	FAIL	FAIL	Exceeds criteria	Exceeds criteria

Total P results in **Table 3-4**, when run through the assessment process in the "NtrntAssessFramework.xlsx" spreadsheet, result in a clear "nutrient impaired" decision, at level I. This is largely driven by the two FAILS for the statistical tests (i.e., TP concentrations were very elevated). But because each nutrient type is assessed separately and TN is PASS for both statistical tests, the TN outcome is considered unclear and would, as a result, move to level II. As a result, the TN-impairment determination would be driven only by the biotic response variables and not by TN (see scenario 10,

‘Mountain and Transitional’ tab, in NtrntAssessFramework.xlsx). However, the most succinct conclusion (again, applying Occam’s razor) is that the problem in this assessment reach is related to P, not N, as can be seen in **Table 3-4**, and only P should be listed. Arranging and reviewing the data as shown in **Table 3-4** should prevent unnecessary chasing of vague results for a nutrient when clearly the alternate nutrient is the issue.

Cases will arise where both nutrients will give mixed results within the two statistical tests, and therefore neither nutrient is clearly the culprit. In such cases, in accordance with the final outcome of the weight-of-evidence assessment, N and P should probably both be listed as probable causes.

3.2.4 Examples of Nutrient-impairment Decisions

Below are 3 assessment reach examples and their outcomes, to demonstrate the process.

(1) The assessment reach is in western MT and has 6 sampling sites. Each site has been sampled 2 times for nutrient concentrations (TN, TP) and once for benthic Chl *a*. **Action:** The nutrient samples ($n = 12$) are assessed, by type (TN or TP), using the two statistical tools, which will result in PASS or FAIL for each test. Both TP tests are FAIL, but the TN tests are both PASS. Each of the six Chl *a* sampling events (each comprised of 11 replicates which have been reduced to a sampling-event average) are independently compared to the criteria. One of them exceeds $120 \text{ mg Chl } a/m^2$, so declare Chl *a* as ‘Exceeds Criteria’ for the assessment reach. The data suggest a TP problem but not a TN problem, per methods in **Section 3.2.3** above. TP is listed as the cause, and further data collection and assessment for TN is not necessary.

(2) The assessment reach is on an eastern MT plains stream. There are 3 sampling sites where nutrients have been sampled 4 times and DO has been continuously monitored by deployed instrument for two summer months, at one site. **Action:** The nutrient samples ($n = 12$) are assessed, by type (TN or TP), using the two statistical tools, resulting in PASS or FAIL for each test. Both TN tests are FAIL, TP tests are mixed (1 PASS, 1 FAIL). Daily DO deltas from the long-term DO dataset should be calculated and compared to the DO delta threshold of 5.3 mg/L . Because this is a long-term dataset, close attention should be paid to the percent of DO deltas exceeding the threshold; if $>10\%$, DO would be declared ‘Exceeds Criteria’ for the assessment reach¹¹. Both TN and TP are suspected (N much more strongly) and should both be listed.

(3) The assessment reach is in western MT and the assessment has gone to a 2nd year of data collection. There are four sites. Nutrients have been collected at the 4 sites three times, benthic Chl *a*/AFDW once at each site, macroinvertebrate samples have been collected at 3 sites once each, and twice at the 4th site, and diatom samples have been collected at all 4 sites two times each. **Action:** All data from both years are first routed through the level I decision framework. The nutrient samples ($n = 12$) are assessed, by type (TN or TP), using the two statistical tools, which will result in PASS or FAIL for each test. Both TP are FAIL, and both TN tests are PASS. Each of the four Chl *a* and AFDW sampling events (each comprised of 11 replicates which have been reduced to a sampling-event average) are independently compared to the criteria. One of them exceeds $35 \text{ g/m}^2 \text{ AFDW}$, which is sufficient to declare Chl *a*/AFDW as ‘Exceeds Criteria’ for the assessment reach. Each macroinvertebrate HBI metric score where there is only one observation per site (three sites) is considered independently. For the 4th site, the two temporally-

¹¹ If DO deltas $>5.3 \text{ mg/L}$ comprise $< 10\%$ of the dataset, consider if the site has a strong presence of macrophytes or not. If macrophytes are very common, the site could be declared as ‘Meets Criteria’. If macrophytes are not common, it could be declared ‘Does Not Meet Criteria’. Consult Standards Section for further assistance.

collected HBI scores are averaged. One of the preceding macroinvertebrate HBI scores is >4, thus 'Exceeds Criteria' would be declared for the macroinvertebrate category for the assessment reach. If the diatom increaser taxa scores (all 8) were each <50% probability of impairment, then the diatom metric score would be declared as 'Meets Criteria' for the assessment reach. The assessment reach is found to be impaired for TP at level I without having to use the macroinvertebrate results. For TN, the assessment could move to level II assessment and this would show nutrient impairment; but that outcome is driven purely by biometrics, which are sensitive to both nutrients. The overall dataset, per methods in **Section 3.2.3** above, suggests a TP problem but not a TN problem. TP is listed, and further data collection and assessment for TN is not needed.

3.2.5 Overwhelming Evidence of Nutrient Impairment-All Regions

Some circumstances related to excess nutrient pollution are severe enough that a rigorous data collection effort is not required. Photo documentation will suffice. Below are listed conditions that can be considered overwhelming evidence; these apply equally to wadeable streams across the state. These conditions are likely to be intertwined with organic pollution problems.

- Fish kills involving massive growths of senescing algae mats. These mats may be attached to the bottom or floating. Dissolved oxygen levels at dawn will likely be less than 1 mg/L.
- Filamentous algal growth covering the entire bottom from bank to bank and extending continuously for a substantial longitudinal distance (> 150m). Use the photographs below (**Figure 3-2** and **3-3**) as a guide. Don't confuse these conditions with sporadic, longitudinally-patchy growths of heavy filamentous growth, in between which there is lighter algal growth. The latter are not extreme enough to warrant overwhelming evidence, and should be sampled/assessed per the method earlier described.



Figure 3-2. Photographs of heavy, bank-to-bank and longitudinally continuous Cladophora growth
Left photo is from (Sandgren, et al., 2004).



Photo courtesy Dr. Vicki Watson.

Figure 3-3. Massive *Cladophora* growth in the Clark Fork River, MT, 1984.

This nuisance alga is aptly named “blanket weed”.

4.0 NUTRIENT IMPAIRMENT ASSESSMENT METHODOLOGIES: WADEABLE STREAMS IN THE MOUNTAIN AND TRANSITIONAL REGION

The following subsections describe assessment methods best suited for use in mountainous streams and streams that transition between mountains and plains. Analysis shows that level IV and level III ecoregions are the most useful classification tool for defining nutrient zones (Varghese and Cleland, 2005), and nutrient criteria have been developed using ecoregions as the base zoning system (Suplee *et al.*, 2008). Consideration has also been given to the legal classification system for streams (B-1, C-3, etc.) which defines the streams’ designated beneficial uses. There is a very high degree of correspondence between streams with salmonid fish among their beneficial uses (A-closed, A-1, B-1, B-2, C-1, C-2) and certain groups of ecoregions. Specifically, the mountainous level-III ecoregions (15, 16, 17, and 41) plus specified level-IV ecoregions along the Rocky Mountain front — Level IVs that are subunits of the level-III Northwestern Glaciated Plains (42) and Northwestern Great Plains (43) ecoregions — comprise a group well suited for assessment methodologies presented in this section. Four (4) additional level IV ecoregions (42l, 42n, 43o, 43t) that were not presented in Suplee *et al.* (2008) have been added to the group. These four level IV ecoregions are also transitional along the Rocky Mountain Front and comprise regions in which all or virtually all waterbodies are classified as supporting salmonid fishes among their beneficial uses. The regions are shown in **Table 4-1**.

Table 4-1. Ecoregions (levels III and IV) in which Assessment Methods in this Section Best Apply

Ecoregion Scale	Ecoregion Name	Ecoregion Number
Level III	Northern Rockies	15
Level III	Idaho Batholith	16
Level III	Middle Rockies	17
Level III	Canadian Rockies	41
Level IV	Sweetgrass Uplands	42l
Level IV	Milk River Pothole Upland	42n

Table 4-1. Ecoregions (levels III and IV) in which Assessment Methods in this Section Best Apply

Ecoregion Scale	Ecoregion Name	Ecoregion Number
Level IV	Rocky Mountain Front Foothill Potholes	42q
Level IV	Foothill Grassland	42r
Level IV	Unglaciaded Montana High Plains	43o
Level IV	Non-calcareous Foothill Grassland	43s
Level IV	Shields-Smith Valleys	43t
Level IV	Limy Foothill Grassland	43u
Level IV	Pryor-Bighorn Foothills	43v

Note: The level IV ecoregion “Unglaciaded Montana High Plains” (43o) has more than one polygon in Montana. Only the polygon located just south of Great Falls, MT should be considered part of the transitional streams group. Also, the level IV ecoregion “Foothill Grassland” (42r) has polygons associated with both the Middle Rockies *and* Canadian Rockies level III ecoregions. 42r polygons are associated with the level III ecoregion (either Middle Rockies or Canadian Rockies) against which they abut.

4.1. ASSESSMENT OF BENTHIC ALGAL GROWTH

For wadeable streams, we recommend that site-average benthic algae densities of 120 mg Chl *a*/m² and 35 g AFDW/m² be used as thresholds (i.e., maximum allowable levels) to prevent impact to the fish and associated aquatic life uses (i.e., to maintain DO standards in DEQ-7), and the recreation use (ARM 17.30.637(1)(e)). Details on how these values were derived are in **Appendix B**.

Note: AFDW results from core samples should never be included in determining a site’s average AFDW. The method measures organic material from the entire core sample, not just the surface where the algae are growing, and will therefore over-report AFDW.

Each sampling event result should be considered on its own merits when using the decision spreadsheet (NtrntAssessFramework.xlsx) and completing the assessment. That is, if 3 sampling events for benthic alga growth were undertaken and 1 of the Chl *a* averages exceeds the recommended threshold, then the conclusion for the assessment reach for the benthic algae category would be “exceeds 120 mg Chl *a*/m²”.

4.2 ASSESSMENT USING BIOMETRICS

Biometrics based on diatom algae are stressor-specific (e.g., address nutrient pollution) and apply to specific regions. A diatom sample that indicates >51% probability of impairment by nutrients indicates the sample is from a site manifesting an excess nutrient problem. Details on how the diatom biometrics were developed and the thresholds derived are presented in the periphyton SOP (Montana Department of Environmental Quality, 2011b).

Always consider cautiously the results from samples collected very early and very late in the sampling season. Algae are a successional community, and if you sample too early, you will sample fewer 'pioneer' species and too late, you will start seeing the community as a whole die off - some taxa sooner than others. These changes can affect metric results.

Various biometrics based on macroinvertebrates were reviewed. We selected the Hilsenhoff Biotic Index (HBI) as the best tool for assessing nitrogen and phosphorus pollution problems. An HBI score of 4.0 should be used as the threshold (i.e., maximum allowable value) to prevent impact to fish and associated aquatic life uses. Details on how the biometrics were selected and the thresholds derived are presented in **Appendix B**.

Each sampling event result for a biometric should be considered on its own merits when using the decision spreadsheet (NtrntAssessFramework.xlsx) and completing the assessment. That is, if 2 sampling events for macroinvertebrates were undertaken and 1 of the results was an HBI score of 5.0, then the conclusion for the assessment reach for the macroinvertebrate category would be ">4.0" (i.e., exceeds).

5.0 NUTRIENT IMPAIRMENT ASSESSMENT METHODOLOGIES: WADEABLE STREAMS IN THE PLAINS REGION

Table 5.1 below shows areas of the state in which the methods of this section best apply. Essentially, the methods apply to all of ecoregion 42 (Northwestern Glaciated Plains) and ecoregion 43 (Northwestern Great Plains) *except for* the level IV ecoregions along the Rocky Mountain Front which are being lumped with the mountainous ecoregions (see **Table 4-1**).

Table 5-1. Ecoregions (level III) in which Assessment Methods in this Section Best Apply

Some level IV ecoregions associated with the level IIIs shown are excluded; these are listed below each level III.

Ecoregion Scale	Ecoregion Name	Ecoregion Number
Level III	Northwestern Glaciated Plains	42
<i>Level IV ecoregions of the Northwestern Glaciated Plains <u>not</u> in the Warm Water Fishery Class:</i>		
Level IV	Sweetgrass Uplands	42l
Level IV	Milk River Pothole Upland	42n
Level IV	Rocky Mountain Front Foothill Potholes	42q
Level IV	Foothill Grassland	42r
Level III	Northwestern Great Plains	43
<i>Level IV ecoregions of the Northwestern Great Plains <u>not</u> in the Warm Water Fishery Class:</i>		
Level IV	Unglaciated Montana High Plains	43o
Level IV	Non-calcareous Foothill Grassland	43s
Level IV	Shields-Smith Valleys	43t
Level IV	Limy Foothill Grassland	43u
Level IV	Pryor-Bighorn Foothills	43v

Note: The level IV ecoregion "Unglaciated Montana High Plains" (43o) has more than one polygon in Montana. Only the polygon located just south of Great Falls, MT is excluded from the Warm Water Fishery Class.

5.1 ASSESSMENT USING BIOMETRICS

Biometrics based on diatom algae are stressor-specific (e.g., address nutrient pollution) and apply to specific regions. A diatom sample that indicates **>51%** probability of impairment by nutrients indicates the sample is from a site manifesting a nutrient problem. Details on how the diatom biometrics were developed are presented in the periphyton SOP (Montana Department of Environmental Quality, 2011b).

Each biometric sampling event result should be considered on its own merits when using the decision spreadsheet (NtrntAssessFramework.xlsx) and completing the assessment. That is, if 2 sampling events for diatoms were undertaken and 1 of the results was “65% probability of impairment by nutrients”, then the conclusion for the assessment reach for the diatom category would be “>51%,” (i.e., exceeds).

Note: Diatom biometrics for the plains region have an inherently high false negative rate (62%; i.e., the chance that the metric declares a truly nutrient-impacted site as having no nutrient impact). This fact is given consideration, in that the resulting decisions in the spreadsheet (NtrntAssessFramework.xlsx) lean somewhat to the protective side.

Always consider cautiously the results from samples collected very early and very late in the sampling season. Algae are a successional community, and if you sample too early, you will sample fewer 'pioneer' species and too late, you will start seeing the community as a whole die off - some taxa sooner than others. These changes can affect metric results.

5.2 ASSESSMENT USING THE DIFFERENCE BETWEEN THE DAILY MAXIMUM DISSOLVED OXYGEN CONCENTRATION AND THE DAILY MINIMUM DISSOLVED OXYGEN CONCENTRATION (DELTA)

We recommend that the magnitude of the daily DO concentration change (daily maximum minus the daily minimum, or *delta*) be used to assess plains streams. Elevated daily DO delta values indicate high productivity and the potential for DO standards exceedances (per DEQ-7) that would impact fish and aquatic life. We suggest that a DO delta of 5.3 mg/L be used as the threshold. **Assessors need not wait 30 days to take subsequent DO measurements at a site; each DO sampling event may be considered on its own merits.** Details on how the DO threshold was identified are provided in **Appendix C**.

Each DO sampling event result should be considered on its own merits when using the decision spreadsheet (NtrntAssessFramework.xlsx) and completing the assessment. That is, if 5 sampling events for DO delta were undertaken and 1 of the DO deltas exceeds the recommended threshold, then the conclusion for the assessment reach for the DO delta category would be “exceeds 5.3 mg/L”. Further consideration may be needed if the data were collected long-term¹². **Note:** DO deltas in the plains region have an inherently high false negative rate (63%; i.e., the chance that the DO deltas indicate that a truly

¹² If DO deltas >5.3 mg/L comprise < 10% of the dataset collected using an instrument deployed at least 14 days, consider if the site has a strong presence of macrophytes or not. If macrophytes are very common, the site could be declared as ‘Meets Criteria’. If macrophytes are not common, it could be declared ‘Does Not Meet Criteria’. Consult Standards Section for further assistance.

nutrient-impacted site has no nutrient impact). This fact is given consideration in that the resulting decisions in the spreadsheet (NtrntAssessFramework.xlsx) lean somewhat to the protective side.

5.2.1 Deploying a Continuous DO Monitoring Device in Wadeable Plains Streams

If a continuous monitoring device is to be deployed (e.g., YSI 6600 sonde), we recommend that at least one (1) full day of data be collected to properly calculate a daily DO delta. The day of deployment and the day of retrieval are usually truncated, and so at least one full day in between assures the necessary data are collected. We recommend a fifteen minute time step for monitoring, as that has worked well in our experience and provides good data resolution. Initial calibration, as well as drift from calibration—which is determined at the time the unit is retrieved—should be documented per the project's QAPP and or SAP.

5.2.2 Instantaneous DO Monitoring in Wadeable Plains Streams

Daily DO minimum and maximum concentrations each need to be obtained, and can be collected using a hand-held instrument. The daily DO minimum needs to be collected starting in the pre-dawn hours, up to as late as 8:00 am. The daily DO maximum will *usually* occur between 2:30 pm and 5:00 pm; observations can be collected every 15-30 minutes during this time to identify the highest value. Continue monitoring after 5:00 pm if observations are still climbing. Further details on how these time frames were identified are provided in **Appendix C**.

The YSI 85 instrument has a 50 reading, manual-entry memory which can be used for collecting DO maximums. With the unit on and the sensor properly deployed, depress the ENTER button for two seconds to record an instantaneous observation. Data may be downloaded later.

For the purpose of calculating DO delta, at least 3 DO sampling events (i.e., 3 different days) should be taken in each assessment reach; if collected at the same site, they do not need to be collected 30 days apart (e.g., 3 days in a row is OK).

5.2.3 BOD₅

We recommend that biochemical oxygen demand, or BOD₅ (also called just BOD), be used to assess plains streams at level II. We recommend a threshold of 8.0 mg/L be used. Each BOD sampling event result should be considered on its own merits when using the decision spreadsheet (NtrntAssessFramework.xlsx) and completing the assessment. That is, if 3 sampling events for BOD were undertaken and 1 of the BODs exceeds the recommended threshold, then the conclusion for the assessment reach for the BOD category would be ">8.0 mg/L" (exceeds).

5.2.4 Algal and Macrophyte Indicators of Nutrient Enrichment in Wadeable Plains Streams

The Fish Cover/other form (see periphyton SOP, (Montana Department of Environmental Quality, 2011b)) should be filled out when assessing plains streams. Although not required to fill out the form, we recommend that the dominant macrophytes be identified, which will help with your assessment back in the office using the information below.

In the Northwester Glaciated Plains ecoregion, streambed cover by filamentous algae should generally be less than 30% for a single sampling event and less than 25% for the summertime average (Suplee, 2004). These data can be collected visually using the Fish Cover/Other form, which is provided in the

periphyton SOP (Montana Department of Environmental Quality, 2011b). (Although a somewhat tangential issue, the presence of a healthy and widely distributed macrophyte community should be taken as indicative that the stream has a reasonable level of morphologic stability; stream instability has been found to be a major factor in controlling algae and macrophyte dynamics in prairie streams [Suplee, 2004]).

Throughout the plains region, attention should be paid to the types of macrophyte species present. We have observed that northern watermilfoil (simultaneously known as *Myriophyllum exalbescentis*, *Myriophyllum sibiricum*, and *Myriophyllum spicatum* L. var *exalbescentis* (Muenscher, 1944). DiTomaso and Healy (2003) is extremely common throughout the Northwestern Glaciated Plains and Northwestern Great Plains ecoregions, as has been observed by others (Klarich, 1982). However, in stream sites where high nutrient enrichment is occurring, we have observed northern watermilfoil's (and other macrophyte's) near-complete replacement by coontail (aka hornwort), *Ceratophyllum demersum*¹³ Coontail is a rootless, free floating macrophyte—though it can anchor itself to bottom substrates via specialized buried stems—that can proliferate in streams which are being heavily loaded with nutrients (DiTomaso and Healy, 2003). In this it is similar to floating and benthic algae in that it relies on water-column nutrients for growth, because it does not take up nutrients from the sediment via roots, as other macrophytes do. Choking mats of coontail, or its presence to the exclusion of other macrophytes, should be taken as a strong indicator of nutrient over enrichment. Close-up and panoramic photos should be taken to record the extent of the problem, and aide identification of the plants in-office.

Finally, we documented during the Box Elder Creek dosing study that *Chara* spp. (commonly called stonewort or muskgrass) were greatly depressed in number in the nutrient-dosed reaches compared to the Control reach, and also compared to the pre-dosing period. *Chara* spp. are a branched form of algae, are an important component of natural aquatic ecosystems (DiTomaso and Healy, 2003), and are often associated with clean water.

6.0 ACKNOWLEDGEMENTS

We would like to thank Dr. Vicki Watson and her students for the many years of work she has carried out in support of DEQ projects. These projects (e.g., the reference streams project) have provided the basic data required to develop many of the guidelines in this document. We would also like to thank all of the DEQ staff and field crews who, over the years, have collected mounds of data that also support this work. Thanks to the Carter County Conservation District for the cooperation and support on the nutrient dosing study. Finally, we want to thank the contractors whose excellent work helped build the foundation on which this document stands: Arun Varghese and Josh Cleland (ICF International); Dr. Loren Bahls (*Hannaesa*); Mark Teply (Cramer Fish Sciences); Wease Bollman (*Rhithron Associates*); and Dr. Jeroen Gerritsen and Dr. Lei Zheng (Tetra Tech).

¹³ Coontail and watermilfoil can readily be distinguished in the field with a good macrophyte guidebook and a hand-held magnifying glass.

APPENDIX A. STATISTICAL CONSIDERATIONS

A.1.0 INTRODUCTION

The numeric nutrient criteria addressed in this appendix are not intended to be ideal standards, i.e., “no sample shall exceed” values. As such, appropriate inferential statistical tests, assumptions about stream sampling frames, etc. must be developed so that the criteria can be correctly applied. This appendix outlines these statistical considerations and provides rationales for the various approaches used. It also provides precautionary points where certain assumptions depart from more conservative statistical thinking, and discusses how improper sampling design has the potential to mislead a conclusion made about a stream’s condition. The key issues addressed herein are:

- Sampling frames, populations, and sampling units for streams, and associated assumptions and precautions
- Consideration of what constitutes our best description of sample independence in streams (spatial and temporal), and associated assumptions and precautions
- Determination of appropriate critical exceedance rates for nutrients (nitrogen and phosphorus)
- Statistical testing procedures and accompanying decision rules
- Minimum sample sizes

A.2.0 SAMPLE FRAME, POPULATION, AND SAMPLING UNITS

All studies involving statistical evaluations of data require that a sample frame, population, and sampling unit be defined. Streams are particularly poor entities for establishing these parameters because streams are an interconnected network rather than discrete entities. Nevertheless, streams are the entities to be sampled so some effort must be made to segregate them into definable units. For the purposes of determining compliance with numeric nutrient criteria, we define the following:

- **Sample Frame:** A wadeable¹⁴ stream segment listed in the Assessment Data Base (ADB) (DEQ 2009, and updates) OR a sub-segment of an ADB stream segment. These segments are referred to here as an “assessment reach”.
- **Population:** All the water flowing through the assessment reach during the time period when the numeric nutrient criteria apply, and the surface area of the stream bottom over which the water flows.

¹⁴ Wadeable streams are perennial and intermittent streams in which large portions of the channel are wadeable during baseflow conditions. For the list of waterbody segments not considered wadeable (i.e., the large rivers), see Flynn and Suplee (2010).

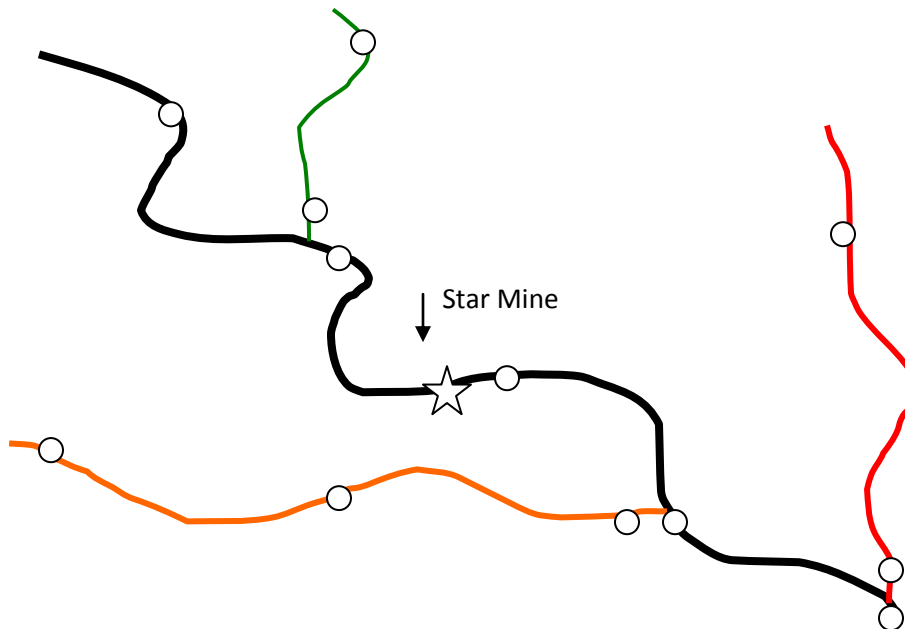
- **Sampling Unit:** A sample collected from the assessment reach that is largely independent of other samples collected within the assessment reach and collected during the time when the numeric nutrient criteria apply.

Assumptions: Each assessment reach (ADB segment or sub-segment) will be made up of a series of sampling sites, or a series of very short study reaches that are essentially sites (**Figure A2-1**). The minimum number of sites on an assessment reach is provided in DEQ SOPs (Montana Department of Environmental Quality, 2005). **Figure A2-1** illustrates the variety of ADB segments that may be found; segment lengths can vary tremendously. For purposes of determining compliance with numeric nutrient standards using statistical methods, it is usually assumed that (1) pollution sources are evenly dispersed along the reach, (2) sampling sites are randomly located along the reach, and (3) each sample is independent of the others (Spatial and temporal independence guidelines for sites are addressed in **Section A.3** below).

In some cases, ADB segments may have pollution problems (hotspots) concentrated only in a particular part of the stream, say, the last 5 stream miles. In such cases, it may not make sense to view the original ADB segment as the best possible sampling frame. That is, it would be better to further stratify the sample frame and, thus, the population of interest. This will prevent distortion of results caused by mixing together, for common analysis, data from the relatively un-impacted sub-segment with data from the impacted sub-segment. For example, in **Figure A2-1** it might be prudent to consider the sub-segment upstream of the Star Mine as a sampling frame apart from the sub-segment below the mine. Stratification is common in studies employing purely random sampling, where it is referred to as stratified random sampling (Cochran, 1977). Stratification allows maximal precision of estimates for minimal sampling effort (Norris, et al., 1992). **The assessor carrying out the analysis on an ADB segment will have to judge if further stratification is warranted.** If it is warranted, then sampling requirements, described above and further detailed below, would apply to *each* of the new sub-segments (aka assessment reaches), individually.

Precautionary Considerations: Pollution sources are rarely evenly-dispersed along stream segments, violating assumption 1 above. And purely random sampling is usually not practical due to stream access issues, etc. Targeting only the known or potential pollution “hotspots” — even within an assessment reach that has been broken out from a larger ADB segment — could over represent the hotspots and distort the statistical tests. Sampling and analysis plans (SAPs) should proceed with goal-oriented sampling (U.S.Environmental Protection Agency, 2000) that works towards striking an equitable balance between the number of hotspot sites and the number of un- or minimally impacted sites *within the defined assessment reach*. That is, the aggregate of collected samples should be representative (U.S. Environmental Protection Agency, 2002) of the assessment reach as a whole. Advanced knowledge and expertise of the field will be needed to accomplish this (Norris, et al., 1992), and modifications to the assessment reach boundaries can be made on-the-fly during field work, if deemed necessary. It is possible to sub-segment a stream reach to the point where, for a particular assessment reach, there really is little left but hotspots; if this is the case, then the hotspots *are* representative of the assessment reach. As a general rule, it is better to lump than split to avoid unnecessary sampling and administrative work. **The requirement to create reasonably uniform assessment reaches is inherently in conflict with the need to “lump” for the purpose of keeping assessments as simple as possible. Judgment is needed to balance these two opposed factors and come up with an optimal sampling strategy.**

Although this quasi-systematic approach is not a substitute for truly random sampling it will, if carried out properly, achieve good sample interspersion and representativeness. For further discussion of randomization vs. interspersion approaches, see page 196 of Hurlbert (1984).



Example sampling sites (hollow dots) are shown along each segment.

Figure A2-1. Four different stream reaches (shown by different colors), each representing 1 sampling frame (ADB stream segment)

A.3.0 DETERMINING SAMPLE INDEPENDENCE

According to definitions in Hurlbert (1984), much sampling carried out by DEQ on individual streams tends to violate spatial and temporal independence assumptions and results in pseudoreplication. For example, samples collected over time at a site can be serially correlated, which precludes temporal independence (Hurlbert, 1984). However, the statistical views advocated by Hurlbert are not universally supported; contrary opinions on the matter can be found in the literature (Stewart-Oaten and Murdock, 1986; Stewart-Oaten, et al., 1992; Osenberg, et al., 1994) and have led to what one journal referred to as a “healthy debate” (*Ecological Applications*, volume 4, No. 1, 1994). In general, more needs to be known about detection of non-independence and the frequency with which temporally independent samples can be collected (Underwood, 1994).

Time-series collected samples from a site may be used in inferential statistical testing, if used cautiously; this requires that one assumes that actual trends in time are identical in magnitude and direction for all the sites across the study (Norris and Georges, 1993). Osenberg *et al.* (1994) examine time-series serial correlation of physical and biological measurements in a BACI (Before-After-Control-Impact) study and conclude that, in the marine environment they study, sampling can occur at a site every 60 days without yielding substantial serial correlation.

DEQ recognizes the issue of temporal pseudoreplication, but also needs to be practical about the reality of sampling streams which, by their very nature, make collection of independent samples difficult. In DEQ's reference project (Suplee, et al., 2005), 30 days has generally been used as a minimum time span between sampling events at a site to infer temporal independence of water samples. This time span was based on the experiential observation that, during the brief Montana summer, substantial changes in flow, temperature, and vegetation (both riparian and instream) occur from month to month, changes that would likely effect water quality. But Stewart-Oaten *et al.* (1986) recommend that the assumption of temporal independence be tested, rather than assumed. The Durbin-Watson test statistic is widely used to check for time-series serial correlation. Stream sites with monthly nutrient sampling during the summer were available in Montana, and some of these sites were tested using the Durbin-Watson statistic. Results are shown in **Table A3-1** below.

Table A3-1. Durbin-Watson Values for Time-series Collected Nutrient Samples at Selected Sites

All Samples were Collected Approximately 30 Days apart Nutrients Showing Probable Time-series Serial Correlation (95% Confidence Level) are Highlighted.						
Stream Site	Months Sampled	Time Range	n	Total N	Nutrient Total P	NO ₂₊₃
Rock Creek Site 2	June, July, Aug, Sept	2001-2004	12	1.18	1.43	2.3
Clark Fork R. at Deer Lodge (site 9)	July, Aug, Sept	1998-2006	25	1.81	1.78	1.68
Clark Fork R. above Little Blackfoot R. (site 10)	July, Aug, Sept	1998-2006	26	2.01	1.57	1.46
Clark Fork R. above Flathead R. (site 25)	July, Aug, Sept	1998-2006	26	1.76	1.21	2.08

In general, Durbin-Watson values around 2 mean there is no serial correlation, whereas values greater than approximately 2.5 or less than about 1.5 lead one to suspect negative or positive serial correlation, respectively (Neter, et al., 1989; Ott, 1993). What can be concluded from this limited analysis? Most nutrients did not show serial correlation, and one of the three that did is borderline cases (statistic =1.43, but power of test very low). Overall, it appears that serial correlation is present in nutrient samples collected a month apart, but the effect is very weak. It is evident that 30-day separated water samples can provide a fairly high degree of independence for nutrients.

DEQ is aware that spatial independence is also a concern. Water flows from upstream to downstream, consequently influencing the spatial independence of downstream sampling sites. No generally applicable spatial minimums were found as of this writing. U.S.EPA guidance (USEPA, 2002) generally glosses over the topic of spatial independence in streams.

To address spatial independence, we tested a Montana dataset. We used the pre-dosing baseline data collected as part of the Box Elder Creek nutrient dosing study (Montana Department of Environmental Quality, 2010a). We found that total nutrient samples collected within hours of one another at two sites located 0.73 stream miles apart were not spatially correlated. We compared nutrient samples collected from the Low Dose site to those collected on the same day at the High Dose site which is 0.73 miles downstream. Box Elder Creek is perennial and was flowing during all sampling events. No tributary intervenes between the sites. Samples were collected within 1-2 hours of one another, during the summer index period. We only considered samples collected *prior to* nutrient dosing, as these are comparable to what one would encounter during routine stream sampling/assessment. Using the Rank von Neumann test (U.S.Environmental Protection Agency, 2006), we found that there was no serial correlation for total N or total P (i.e., we could not reject the null hypothesis "no serial correlation"), at an alpha of 0.05. There was serial correlation for Soluble Reactive Phosphate (SRP). We were unable to

assess soluble N as there were too many non-detects in the datasets, which led to too many rank-ties; too many rank-ties precludes proper statistical evaluation (Gilbert, 1987).

Spatial independence can therefore be established (albeit as rules of thumb) for total nutrients as a minimum of about 1 mile between two sites. Other factors leading to spatial independence include a tributary confluencing on a stream between two sampling sites, or if major land form or land use changes occur along the reach (Montana Department of Environmental Quality, 2007; Montana Department of Environmental Quality, 2011a).

Giving consideration to our findings, below are guidelines for establishing independence of samples collected within an assessment reach:

- Sites (or short reaches equivalent to sites) should be located a minimum of 1 stream mile apart.
- Sites may be placed < 1 mile apart along the assessment reach if there is a flowing tributary confluencing with the segment between the two sites.
- Try to collect water samples starting at the downstream end of the assessment reach moving upstream, to avoid re-sampling the same water.
- Land use changes and land form changes should be considered and can be used to help define (1) breaks between assessment reaches and/or (2) additional sampling sites within an assessment reach.
- Samples collected at the same site (or short reach) should be collected 30 days apart.

Total nutrient samples that meet the above conditions may generally be considered spatially and temporally independent for the purposes of determining compliance with the nutrient criteria. As such, they may be used in inferential statistical analyses and to make conclusions about the assessment reach in question.

Precautionary Considerations: The last bullet above (temporal independence resulting from approximate 30-day time spans) is not applicable for some bioassemblage samples (e.g., macroinvertebrates, fish). These organism populations operate on different (longer) time scales from water samples and diatoms and may show considerable year-to-year stability. Please see **Section 9.0** of Suplee (2004)) and Bramblett *et al.* (2005) for more details on temporal patterns of these biological assemblages. Diatom populations tend to shift quickly, within 1-5 weeks, in response to environmental changes (LaVoie, et al., 2008). Thus, this rate of change is sufficient to be able to consider diatom sampling events spaced 30 days apart as being largely independent of one another.

A.4.0 SELECTION OF INFERENTIAL STATISTICAL TESTS, CONFIDENCE LEVELS, AND ASSOCIATED DECISION RULES

A.4.1 RATIONALE FOR USING TWO INFERENTIAL STATISTICAL TESTS TO HELP DETERMINE COMPLIANCE WITH NUTRIENT STANDARDS

Exhaustive reviews of the pros and cons of statistical tests available for determining compliance with numeric standards have already been published (U.S. Environmental Protection Agency, 2002). For brevity, rather than revisit all the detailed considerations put forward in those documents, recommendations are provided herein concerning what where judged to be the most applicable tests. These recommendations are then followed by a series of decision rules that allow the user to apply the tests in tandem. For purposes of compliance with numeric nutrient criteria, two tests should be used; the Exact Binomial Test and the One-Sample Student's t-test for the Mean.

- Exact Binomial Test: This test assumes data are dichotomous in nature (i.e., only two possible outcomes). For compliance with a criterion this reduces to (1) samples that exceed the criterion and (2) samples that do not exceed the criterion. If confidence levels, power, and exceedance rates (more on these below) are established upfront, minimum sample sizes can also be determined. The main disadvantage of the test is that it is blind to exceedance magnitude; that is, it takes no account of whether a sample exceeds the criterion by 1% or 1,000%.
- One-Sample Student's t-test for the Mean: This test does not assume the data take on a dichotomous relationship relative to the criterion. The test compares the mean of the samples in question to the criterion. The desired confidence levels in the test are established upfront. But unlike the Exact Binomial Test, it is greatly influenced by high values and outliers which can skew the dataset mean relative to the bulk of the other samples in the dataset. It is also influenced by the proportion of non-detects in the dataset¹⁵.

The Exact Binomial Test is useful for determining sample sizes, and is not influenced by large numbers of non-detects in the dataset. In fact, if the magnitude of nutrient criterion exceedances was irrelevant, then the Exact Binomial Test could probably be used by itself. But this is not the case; one must consider the issue of luxury nutrient uptake by algae.

One of the main purposes of establishing nutrient criteria is to control excess algae growth and its effects on water quality. Many benthic and water-column algae have the ability to take up the non-limiting nutrient, be that N or P, in excess of immediate need and utilize it for growth later (luxury nutrient uptake; (Elrifi and Turpin, 1985; Portielje and Lijklema, 1994; Stevenson and Stoermer, 1982). If extracellular nutrient concentrations then decline in the water, growth can still be maintained on intracellular stores (Droop, 1973; Rhee, 1973). Therefore, pulsed loading events of nutrients to streams may allow algae to carry out luxury nutrient uptake which can sustain growth for several cell generations well after the pulse has ended.

¹⁵ For the purposes of using the t-test, users should initially convert all non-detects to 50% of the reported detection limit (USEPA, 2006). If >> than 15% of the dataset will be affected, consult Standards Section.

Luxury nutrients uptake is a kinetics phenomenon dependent on the physiological condition of the algae, duration and magnitude of the nutrient pulse, etc.; complex factors not easily addressed by a simple t-test. But the t-test can help assess the *potential* for luxury nutrient uptake because pulsed loads of elevated nutrient concentrations, if captured during sampling, would increase the dataset mean and would show that mean water quality has exceeded the criterion; this is useful information not provided by the Exact Binomial Test.

Each test possesses strengths the other does not. Therefore, we recommended that the t-test be used in tandem with the Exact Binomial Test via a series of decision rules (**Section 3.0**, main document).

A.4.2 FORM OF THE NULL HYPOTHESIS, ALPHA, BETA, EFFECT SIZE, AND CRITICAL EXCEEDANCE RATE

All of the factors listed in **Section A.4.2's** title are interrelated and influence one another in statistical hypothesis testing. Again, rather than reiterate here the mass of discussion devoted to these topics already covered elsewhere ((U.S. Environmental Protection Agency, 2002; California Environmental Protection Agency State Water Resources Control Board, 2004), we will simply state what we concluded to be the best statistical parameters (form of null hypothesis, alpha, beta, etc.) associated with the two tests (Exact Binomial and One-Sample Student's t-test for the Mean), and provide further explanation where warranted.

A.4.2.1 Form of the Null Hypothesis for the Statistical Tests

For Streams Already on the 303(d) List:

- Null Hypothesis: Waterbody is not in compliance with numeric nutrient standards
- Alternative Hypothesis: Waterbody is in compliance with numeric nutrient standards

For Streams Not on the 303(d) List:

- Null Hypothesis: Waterbody is in compliance with numeric nutrient standards
- Alternative Hypothesis: Waterbody is not in compliance with numeric nutrient standards

In effect, this is a “guilty until proven innocent” approach for streams already considered to have water quality problems, and an “innocent until proven guilty” approach for newly assessed streams California uses the same approach (California Environmental Protection Agency State Water Resources Control Board, 2004).

A.4.2.2 Alpha, Beta, Effect Size

In statistical testing alpha, beta, effect size, and critical exceedance rate interact, and changes in one affect changes in the others. In environmental compliance work, there are strong arguments for attempting to balance type I (alpha) and type II (beta) errors; in doing so, it is important to consider the form of the null hypothesis and the implications for making one error or the other. Basically, each type of error has ramifications; one type of error leads to degradation of the environment, the other type of error leads to unnecessary expenditures on the part of the regulated entity. Working towards balancing type I and II errors is a process which inherently recognizes the consequences of each error type (California Environmental Protection Agency State Water Resources Control Board, 2004, Page 52, Appendix C; Mapstone, 1995, Page 178; Schroeter, et al., 1993; U.S. Environmental Protection Agency,

2002). *Given that* working towards balancing type I and type II errors is a valuable endeavor, here are general recommendations for the parameters to be input into statistical tests for nutrients in wadeable streams:

- Alpha should be about 0.25 or less (equates to $\geq 75\%$ confidence level), depending on the form of the null hypothesis and its implications.
- Beta should be about 0.3 or less (equates to $\geq 70\%$ power), and will vary according to the samples size (more on sample size minimum in **Section 5.0**).
- Effect size (gray zone) should be set at 0.15, per USEPA (2002).

In the statistical spreadsheet tools that accompany this technical appendix (“MT-NoncomplianceTool.xls” and “MT-ComplianceTool.xls”), one or the other file is used depending upon whether you are dealing with a new, unlisted stream (use “MT-NoncomplianceTool.xls”) vs. a 303(d) listed stream (use “MT-ComplianceTool.xls”). You will be able to set alpha, critical exceedance rate (p), and effect size (p_2) in the Exact Binomial Test in both of the files. The program will then return various sample sizes, their associated beta values, and the maximum number of exceedances allowed while still remaining in compliance with the criterion.

For the One-Sample Student’s T-test, you must input alpha and the nutrient criterion in mg/L. The One-Sample Student’s T-tests will then provide a result indicating if the statistical test can or cannot confirm the alternative hypothesis. (The alternative hypothesis will reverse, according to whether you are using the tool for a listed or for a new, unlisted stream).

A.4.2.3 Critical Exceedance Rate

Critical Exceedance Rate: *An estimate of the actual proportion of samples that exceed an applicable water quality criterion. When more than this proportion exceeds the criterion, the standard is not attained (i.e., stream is not in compliance with standard).*

Among the four statistical parameters critical to the Exact Binomial Test—alpha, beta, effect size, and exceedance rate—exceedance rate needs some kind of empirical ground-truthing to assure its validity. The implications of different alpha and beta errors can be understood relative to the form of the null hypothesis, while the effect size (gray zone) is not knowable *a priori*, and is therefore assumed; we recommend an effect size of 0.15 per EPA (U.S. Environmental Protection Agency, 2002). In contrast, an exceedance rate can be estimated using lines of reasoning, empirical evidence and literature values. The considerations used to estimate an exceedance rate for numeric nutrient standards were (1) recommended exceedance rates from EPA (U.S. Environmental Protection Agency, 2002) and (2) long-term benthic algae and nutrient relationships on the Clark Fork River, MT (Consideration (1) and (2) are further detailed below.). We recommend:

- A critical exceedance rate for compliance with numeric nutrient standards be set at 0.2 (20%)

Below are our two major considerations leading to the selection of the 20% exceedance rate.

(1) EPA recommends that, for a number of different polluting substances (e.g., fecal bacteria, conventional pollutants, toxic trace metals, etc.), criteria exceedance rates be set between 0.1 and 0.25

(10 to 25%) to protect beneficial uses (Environmental Research Laboratory-Duluth, 1997; U.S. Environmental Protection Agency, 2002).

(2) The analytical approach described in **2.1** below was undertaken in June 2008, and only considered Clark Fork River data through 2006. Subsequent data collection (through 2009) and a somewhat different approach to ascertaining an acceptable exceedance rate allowed us to update this analysis, as provided in **2.2**. Both analyses (that from 2008 [**2.1**], and the work done in 2011[**2.2**]) arrive at the same basic conclusion, and both are presented here. If readers are already familiar with the work in **2.1**, we recommend you skip to **2.2**.

(2.1)The following analysis was completed in June 2008.

Introduction: Numeric nutrient (TN and TP) and benthic algae (mg Chl *a*/m²) standards have been in place on most of the Clark Fork River in Montana for about 6 years. A systematic collection of nutrient and algae data has been ongoing since 1998. At a number of sites both algae and nutrient data have been collected multiple times each year for nearly 10 years. These data lent themselves well to empirically deriving a numeric nutrient exceedance rate because some river sites almost always exceed the algae standards, while others do not. The question became:

Do sites on the Clark Fork River that routinely exceed the numeric algae standards exceed the river's established numeric nutrient (TN and TP) standards more frequently than sites that do not exceed the numeric algae standards?

Benthic algae levels in excess of 150 mg Chl *a*/m² (maximum) are not to be exceeded during the summer (ARM 17.30.631). Maximum in this case does not refer to a single high repeat measure from a Clark Fork River site; it refers to the mean value of a series of repeat measures (*n* = 15 to 20) that are collected at a site *during a particular sampling event*. Clark Fork River sites are usually sampled several times throughout the summer. It has been noted for some years that, during the summer, some sites are usually above the algae standards, while others are not. TN and TP standards were established on the Clark Fork River (ARM 17.30.631) and, if ultimately met, should keep benthic algae below the nuisance threshold described above. However, an exceedance rate was never explicitly established in the regulations. In carrying out the exceedance rate determination described herein, it is assumed that the magnitude of the TN and TP criteria on the Clark Fork River were accurately determined, and therefore any exceedance rate drawn from this analysis is meaningful.

Methods: Benthic algae and TN and TP concentration data where concurrently available for seven Clark Fork River sites from 1998-2006. Data were restricted to the time period June 30th to October 1st to generally comply with the summer growing season for this ecoregion (Suplee, et al., 2007) and the regulatory timeframe in ARM 17.30.631. Every benthic Chl *a* measurement from a site (*n* = 15-20 per sampling event) collected over time was treated as a repeat measure. This resulted in a grand total of 285 to 333 repeat measures of Chl *a* at each site for the period 1998-2006. A grand benthic Chl *a* mean was calculated for a site by averaging all the repeat measures collected between June 30th and Oct 1st for all available years. Nutrient data collected at the corresponding sites during the same time frames were similarly compiled. At each site nutrients were collected as a single grab sample and, as a consequence, there were fewer data (43 to 78 N or P samples per site). Total N data were not collected; however, Total Kjeldahl Nitrogen (TKN) and NO₂₊₃ were. Therefore, for each site, individual Total N concentrations were calculated by summing the TKN and NO₂₊₃ sample results collected simultaneously during a sampling event.

Next, the Clark Fork River TN and TP criteria concentrations were matched to their corresponding values in the nutrient cumulative frequency distributions for each site, and the associated percentile was recorded. For example, the TN criterion for the Clark Fork River is 0.3 mg/L, and it resulted that at site 9.0 (Clark Fork at Deer Lodge) 0.3 mg TN/L corresponded to the 23rd percentile of site 9.0's cumulative TN frequency distribution. This process was carried out for all 7 sites for both TN and TP. There is a break at the Blackfoot River confluence where the Clark Fork's upstream TP criterion (0.02 mg/L) differs from that below (0.039 mg/L); each TP criterion was applied as appropriate for a site's location along the river.

Results: **Table A4-1** shows the results for 3 sites that, over the 1998-2006 time period, did not exceed the Clark Fork River's benthic algal biomass criteria. For this group of sites the nutrient criteria exceedance rate (both TN and TP) was, on average, about 8%. That is, nutrient samples whose concentrations exceed the standards occur only about 8% of the time at these sites. **Table A4-2** shows three sites that *did* exceed the benthic algae standard; for this group of sites, the nutrient criteria exceedance rate was, on average, about 58%. Sites in **Table A4-1** (did not exceed algae standard) had a range of exceedance rates (TN and TP) from 0.1%-24%, and sites in **Table A4-2** (exceed algae standard) had a range of exceedance rates from 27.7% to 88%. The remaining site examined (Site 12; Clark Fork River at Bonita), which is not presented in **Tables A4.1** or **A4.2**, had a mean algae density (144 mg Chl *a*/m²) so close to the algae standard it was considered borderline. Site 12's exceedance rate was 30.8% for TN, 68% for TP.

Table A4-1 Sites on the Clark Fork River (CFR) Not Exceeding the Maximum Benthic Algae Standard (Growing Season, 1998-2006)

			Percentile in Site's Nutrient Frequency Distribution Matching CFR Standard		Criteria Exceedance Rate (%)	
Clark Fork River Site #	Site Name	Long-term Benthic Algal Biomass (mg Chl <i>a</i> /m ² , growing season) Mean [median]	TN	TP	TN	TP
15.5	Clark Fork above Missoula	96 [80]	90 th	95 th	10.2%	5.4%
22	Clark Fork at Huson	72 [52]	76 th	96 th	24.0%	3.8%
25	Clark Fork above Flathead	35 [20]	100 th	99 th	0.1%	1.5%
					Grand Mean:	7.5%
					Grand Median:	4.6%
					Maximum:	24.0%
					Minimum:	0.1%

Table A4-2. Sites on the Clark Fork River (CFR) Consistently Exceeding the Maximum Benthic Algae Standard (Growing Season, 1998-2006).

			Percentile in Site's Nutrient Frequency Distribution Matching CFR Standards		Criteria Exceedance Rate (%)	
Clark Fork River Site #	Site Name	Long-term Benthic Algal Biomass (mg Chl <i>a</i> /m ² , growing season) Mean [median]	TN	TP	TN	TP
9	Clark Fork at Deer Lodge	180 [147]	23 rd	50 th	77.0%	50.0%
10	Clark Fork above Little Blackfoot River	163 [117]	48 th	12 th	52.0%	88.0%
18	Clark Fork at Shuffields	197 [181]	50 th	72 nd	50.4%	27.7%
					Grand Mean:	57.5%
					Grand Median:	51.2%
					Maximum:	88.0%
					Minimum:	27.7%

Discussion: The main assumption of this analysis was that the magnitudes of the Clark Fork River nutrient criteria, which were established as standards for the river, are correct. That is, if the nutrient standards are achieved, then summertime algae levels should be kept below the established nuisance thresholds. It was assumed that, as has previously been shown, both N and P co-limit in the Clark Fork River (Lohman and Priscu, 1992); (Dodds, et al., 1997). It was further assumed that the algae standard (150 mg Chl *a*/m², site mean per sampling event) will protect beneficial uses. Regarding the later, research completed since the Clark Fork River standards were adopted in 2002 show that 150 mg Chl *a*/m² (site mean) is identified as a nuisance threshold by the Montana public majority (Suplee, et al., 2009). If all these assumptions hold true, then reasonable exceedance rates for the 9 year dataset can be derived and used as a case study. It would have been ideal to have a true population of data (rather than a subset of data for a single river over a specific time period) with which to carry out this analysis. But such data are not readily available, and the long-term dataset examined here will have to serve as a proxy.

Comparison of Clark Fork River sites 15.5, 22, and 25 (don't exceed algae standard; **Table A4-1**) vs. 9, 10, and 18 (do exceed algae standard; **Table A4-2**) show a clear separation in the consistency of compliance with the river's numeric nutrient standards. It is clear from **Table A4-2** that if the exceedance rate is about 50% then nuisance algae growth will almost certainly occur. But when the exceedance rate is ca. 5-10%, nuisance algae is unlikely to occur (**Table A4-1**.) For purposes of estimating a protective nutrient criteria exceedance rate, the range of exceedance rates from these site groups needs to be considered as well. Note that an exceedance rate of *as much as* 24% does not result in excess benthic algae in some cases (site 22; **Table A4-1**). On the other hand, notice that an exceedance rate of *as little as* 27.7% can result in non-compliance with the algae standard (site 18; **Table A4-2**). Thus, an exceedance rate around 25% probably represent a threshold; if about 25% of the dataset exceeds the nutrient criteria, then there are roughly equal odds that the site could have nuisance algae (or not). This is partially supported

by the fact that the single site with borderline algae conditions (site 12, Clark Fork River at Bonita; 144 mg Chl *a*/m²) had a TN exceedance rate of 30.8%.

Conclusion: These analyses show that over a 9 year period (1998-2006) sites on the Clark Fork River that have consistently exceeded the nuisance algae standard (150 mg Chl *a*/m², summertime max) have TN and TP exceedance rates with a central tendency around 54%. On the other hand, sites that did not exceed the benthic algae standards had TP and TN exceedance rates with a central tendency around 6%. Within each group (sites that do not exceed algae standards, those that do; **Tables A4-1** and **A4-2**), individual sites had exceedance rates as high as or as low as about 25%. This suggests that 25% may be an exceedance rate threshold where the ability to assure compliance with the algae standard becomes tenuous. Given that about 50% is certainly too high of an exceedance rate and will not protect beneficial uses, approximately 10% is probably too restrictive, and 25% is borderline, it is recommended that a nutrient exceedance rate be set to 20%.

(2.2) 2011 Analysis.

The 12-year (1998-2009) nutrient and algae dataset for the Clark Fork River was very large, and was first reduced prior to statistical analyses. Data reduction followed the following general pattern: At any given site (e.g., CFRPO-12), for any given year (e.g., 2005), and for any given parameter (e.g., TP concentration), the data were reduced to a monthly mean for each summer month (June, July, August, or September). First, quality control duplicates collected on the same day were reduced to a mean (TN data was not analyzed directly until 2009 and so, for 1998-2008 data, TN is the sum of TKN and NO₂₊₃ samples collected simultaneously during a sampling event). Next, the mean of all individual days where sampling occurred within a month was calculated, resulting in a monthly mean. Nutrient sampling effort varied considerably from site-to-site and from year-to-year, and we did not want heavily sampled months or years to be over-represented in the dataset in the final analysis. In the manner we reduced the data, therefore, each monthly value carries equivalent weight, with some summer months being better characterized (i.e., sampled more days) than others.

For benthic algae samples, up to 20 spatially-dispersed replicates were collected at a site during any given sampling event. Algae sampling events occurred only once a month. Thus, for a given site/year/month, the benthic algae mean calculated was the value used.

We next determined if each mean nutrient concentration, computed on a month-by-month basis, was above or below the Clark Fork River's applicable standards (TP or TN). This was only carried out for sites and times which had corresponding benthic algae samples. Then, we determined the proportion of months during a summer, at a site, that exceeded the river's nutrient criteria. For example, if a site in 2008 was sampled in June, July, August, and September, and June and August exceeded the TN standard, the TN exceedance rate for summer '08 would be 0.5 (50%). Each exceedance rate was then associated with its corresponding "Max Summer Chl *a*" value (exceedance rate as X, Max Summer Chl *a* as Y). Max Summer Chl *a* is the highest mean monthly Chl *a* value encountered during the summer at a site, per ARM 17.30.631. TN or TP data that were collected *after* the Max Summer Chl *a* event occurred were not included (e.g., if the Max Summer Chl *a* occurred in August, we did not include in the analysis the September TN or TP data for that site/year). Finally, least squares regressions (with 95% confidence intervals) were run for TN exceedance rate vs. Max Summer Chl *a* and TP exceedance rate vs. Max Summer Chl *a*, combining all sites and years together. The results are shown on the next page in **Figure A4-1**.

Regression statistics for both regressions were significant ($p < 0.01$). Using the line equations shown in **Figure A4-1**, 150 mg Chl a/m^2 (i.e., the maximum allowable benthic Chl a level for a summer; ARM 17.30.631) equates to a 26% exceedance rate of the TN standard and a 31% exceedance of the TP standard. The equivalent exceedance rates corresponding to the upper 95% confidence intervals (which are more conservative) are about 11% and about 5% for TN and TP, respectively.

These Clark Fork River data demonstrate that, across 10 sites with 12 year's worth of monitoring, there is a significant, definable relationship between benthic algal growth and the frequency of exceedance of the river's nutrient standards. That is, sites which frequently exceed the nutrient standards have higher levels of benthic algae. Sites that experience greater than about 25-30% exceedance of the nutrient standards will develop nuisance benthic algal growth, i.e., growth equal to or greater than 150 mg Chl a/m^2 .

The analytical approach taken in 2008 (**2.1** above) was more coarse than what we have done here, in that it lumped all data by site and then looked to see how often that site—over the long haul—exceeded the nutrient standards. This analysis, in contrast, looks at each site and each summer as an individual event, and then collectively evaluates all the data together, regardless of location along the river (**Figure A4-1**). Interestingly, the overall results between the earlier analysis and the current one are largely the same, in spite of the different analytical approaches. If we continue to assume that the nutrient standards on the Clark Fork River are largely correct in magnitude, then this latest analysis indicates we would want to keep exceedance rates of the applicable nutrient standards between 5-31%, if we want to keep benthic algae below nuisance levels. Since these results correspond nicely to the earlier analysis, we continue to recommend that nutrient criteria exceedance rates be set at 20%.

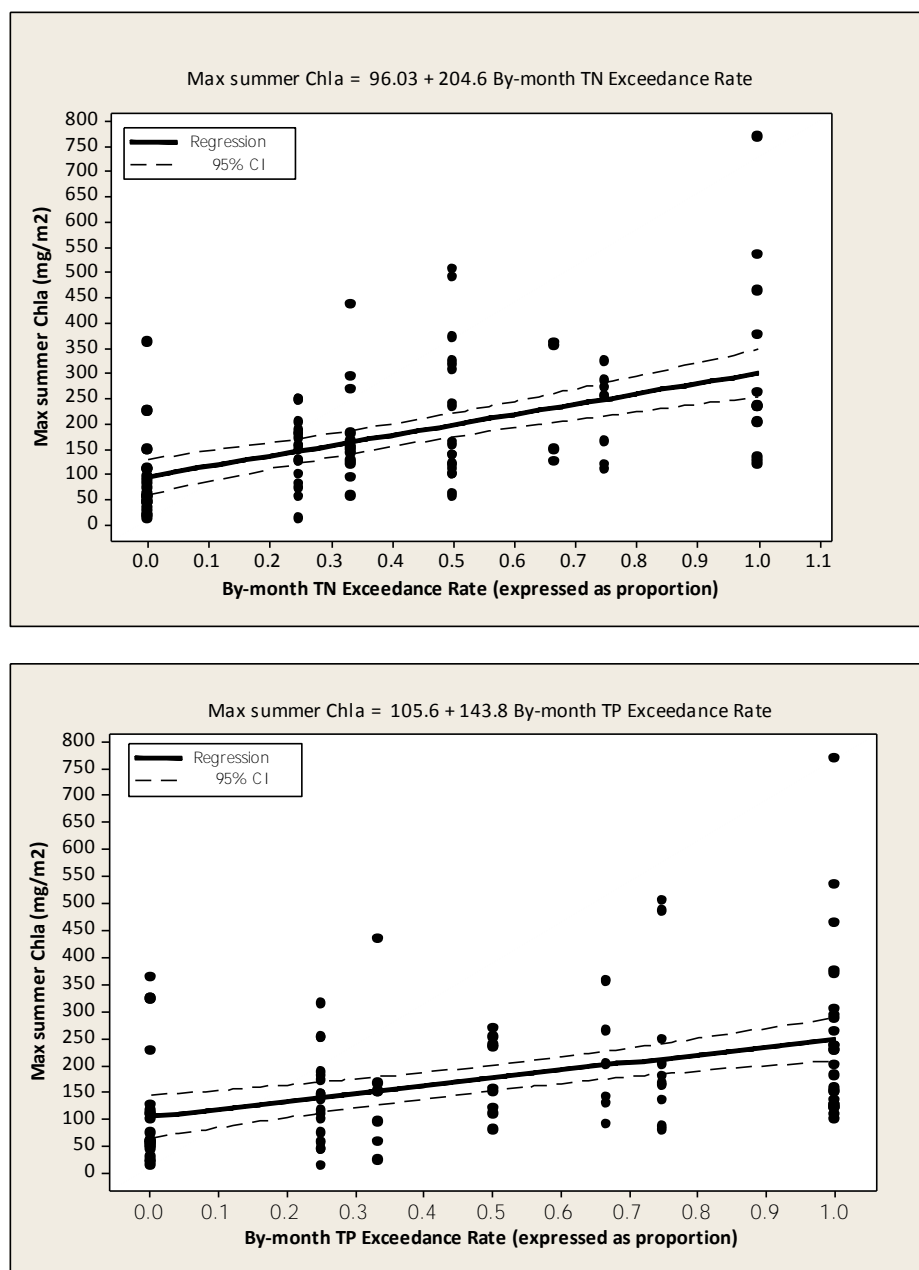


Figure A4-1. Least squares regression for TN exceedance rate vs. Max Summer Chl *a* (upper panel) and TP exceedance rate vs. Max Summer Chl *a* (lower panel), for ten Clark Fork River monitoring sites (1998-2009). Dotted lines are the 95% confidence intervals. Both regressions are significant ($p < 0.01$).

A.5.0 MINIMUM NUMBER OF NUTRIENT SAMPLES

The final consideration is minimum nutrient sample size. A “nutrient” sample refers to a nutrient type, such as TP or TN. Sample sizes apply to each nutrient type, and not to the total number of nutrient samples collected from a stream segment. So, if 7 TN and 7 TP samples were collected from a segment they would not represent 14 samples, but rather 7 of TN and 7 of TP. There is extensive discussion of determining appropriate sample size on a study-by-study basis in USEPA (2002). However, the

recommendations made here for determining compliance with the numeric nutrient standards are meant to apply generally to all Montana wadeable streams, mainly for purposes of 303(d) listing/delisting. *Please note that these sample size minimums do not apply to biological samples (e.g. benthic algae or diatoms) that may be collected concurrently with the nutrient samples.*

For unlisted streams, those for which the form of the null hypothesis is “complies with standard” (**Section A.4.2.1**), the implication for making a type II (beta) error is that a truly non-compliant stream segment would be incorrectly declared compliant. This is a scenario DEQ wants to minimize, and so the probability of such an outcome should be reduced well below 50%, i.e., well below that of a coin flip. The Exact Binomial Test in the accompanying spreadsheet tool can be used to estimate minimal sample sizes. In the test it can be seen that if alpha (type I) error is set to 0.25, exceedance rate (p) to 0.2, and effect size/gray zone (p2) to 0.15 (entered value = 0.35), then a Beta (type II) error of 0.35 is achieved with 12 samples. (Note in the spreadsheet that introducing lower and lower alpha values causes beta error to increase and, therefore, many more samples are needed to try to balance alpha and beta errors.) Twelve samples is about as low an *n* that can be used and still have roughly balanced (0.25 vs. 0.35) alpha and beta errors that are each well below 50%.

For listed streams, a similar approach is used. Listed streams are those for which the form of the null hypothesis is “does not comply with standard”. In this scenario, the implication of making a type I (alpha) error is that a truly non-compliance stream segment is incorrectly declared compliant; again, this is a scenario DEQ wants to minimize. Setting the alpha to 0.25, exceedance rate (p) to 0.2, and effect size/gray zone (p2) to 0.15 (entered value = 0.05), a beta error of 0.14 (14%) can be achieved with 13 samples. This is a reasonable balance of type I and II errors, and provides a total sampling effort about the same as that for unlisted streams. Given these considerations, it is recommended that:

- For new, unlisted stream segments, a minimum of 12 independent samples for any given nutrient be collected for compliance determination.
- For 303(d)-listed stream segments that already have one 1 nutrient criteria exceedance for a given nutrient, a minimum of 13 independent samples (this total can include newly collected as well as previously collected samples) should be used for compliance determination.
- For listed streams with 13-18 total samples that already have 2 or more exceedances for a given nutrient, the default conclusion is that the stream segment has failed the Exact Binomial Test (no further sampling required at this time). Run the t-test as well and incorporate results in decision matrix.
- For listed streams that have > 18 samples for a given nutrient, set alpha to 0.25, exceedance rate to 0.2 and effect size to 0.15 in the Exact Binomial Test, and determine if the reach is (or is not) in compliance with the Exact Binomial Test. Carry out the same for the T-test.
- If a very large dataset (> 300 samples) is available for a particular stream, then lower type I (alpha) and type II (beta) error can be achieved with higher confidence in the results. Use the special feature of the Exact Binomial Test to help define these confidence levels. Confer with Standards Section if needed.

APPENDIX B. DETAILS ON ASSESSMENT METHODOLOGIES FOR WADEABLE MOUNTAIN AND TRANSITIONAL STREAMS

The following provides the rationales used for the selection of the assessment tools. It also provides the rationales for selected impact thresholds. This information is summarized in **Section 4.0** of the main document.

B.1.0 ASSESSMENT OF BENTHIC ALGAL GROWTH

An evaluation of statistical uncertainty in the site averages calculated using DEQ's standard procedure for collecting and analyzing benthic Chl *a* is detailed in **Appendix A** of the Chl *a* SOP (Montana Department of Environmental Quality, 2011c). To summarize: if a benthic Chl *a* sampling event has followed the SOP, DEQ is confident that—for a typical wadeable stream— at least 80% of the time the measured Chl *a* average calculated will be within $\pm 30\%$ of the true average. Given this known variability, decision points pertaining to benthic algae growth and harm-to-uses have been developed, and are further detailed in **Sections B.1.1** and **B.1.2** below

B.1.1 BENTHIC ALGAL CHL *a* LEVELS AND THE RECREATION USE

It is reasonable that, once a site's true average algal level exceeds about 150 mg Chl *a*/m², impairment to the recreational use has occurred. This is shown in **Figure B1-1**. But we also have to account for the uncertainty around the Chl *a* measurement. Shown are the three photographs that bracket the acceptable-unacceptable threshold, per Suplee *et al.* (2009) each with their interval widths (based on the 20 Chl *a* replicates associated with each photo) calculated at the 90% confidence level. Once algae levels have reached the lower bound of photo E (photo E's lower confidence bound = 169 mg Chl *a*/m²), the acceptability threshold has already been exceeded. This is because the public majority finds the algae level shown in the photo to be highly undesirable. The gray zone in **Figure B1-1** represents the zone where public acceptability rapidly transitions from "OK" to "Not OK". Going forward, any measured average Chl *a* value DEQ believes could plausibly be as high as 165 mg Chl *a*/m² (in the gray zone, and at upper confidence bound of photo F, but still below the lower confidence bound of photo E) should be considered an exceedance.

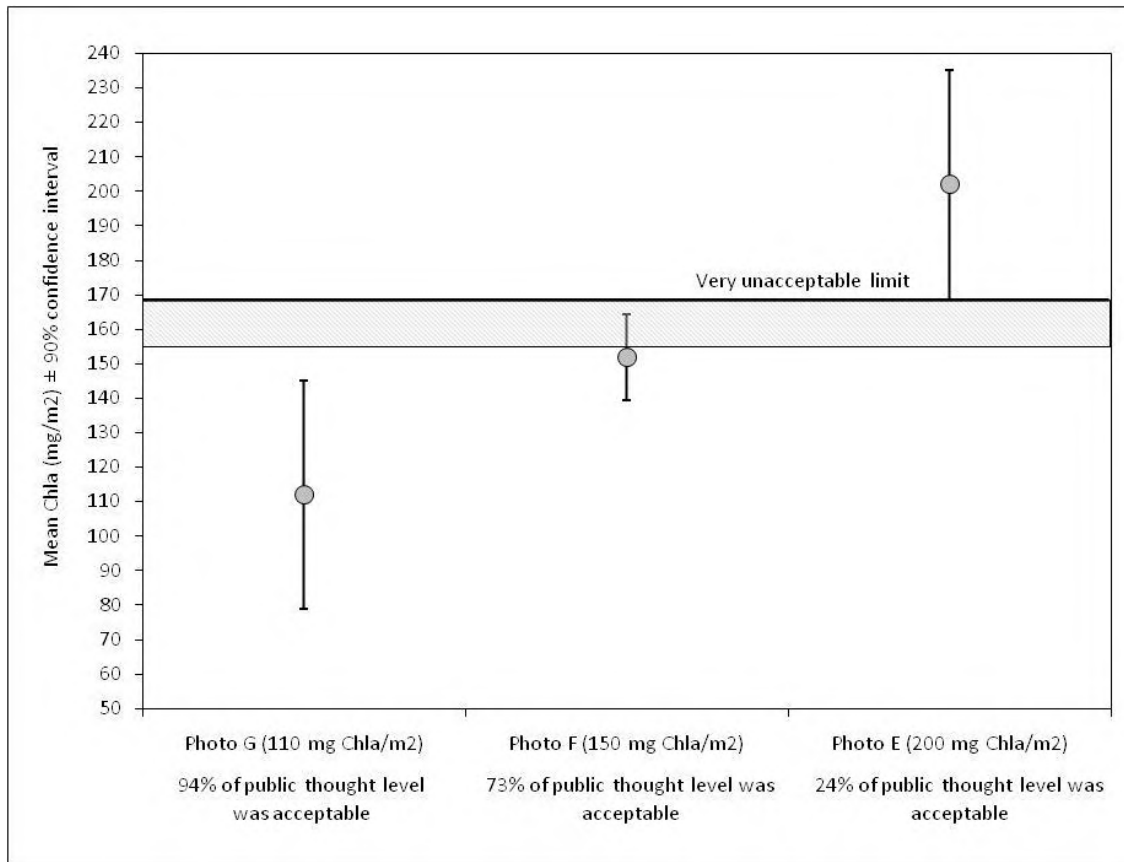


Figure B1-1 Averages (Gray Dots) and 90% Confidence Bands for the Three Photos Bracketing the Acceptable-unacceptable Threshold, per Suplee et al. (2009) The gray band shows the algae level range across which public opinion rapidly shifts from acceptable to unacceptable.

Returning to DEQ's algae-sampling protocol, the average that is calculated for any given sampling event has a definable interval width and, when the upper bound of that interval reaches about 165 mg Chl *a*/m², an impairment at that site should be considered to have occurred. Using the approach outlined in Appendix A of DEQ (Montana Department of Environmental Quality, 2011c) and given that $n = 11$, Coefficient of Variation (CV) = 73%, DEQ can be 80% certain that the true benthic algae average may be as high as 165 mg Chl *a*/m² when the measured average is ≥ 129 mg Chl *a*/m². Therefore, any sampling event for which the measured benthic algal Chl *a* average is ≥ 129 mg Chl *a*/m² should be considered an exceedance, and in violation of ARM 17.30.637(1)(e).

B.1.2 BENTHIC ALGAL CHL A LEVELS RELATIVE TO LATE-SEASON DISSOLVED OXYGEN PROBLEMS, AND POTENTIAL IMPACTS TO FISH AND ASSOCIATED AQUATIC LIFE

In 2009, DEQ commenced a BACIP (Before After Control Impact Paired) design, whole-stream nutrient addition study to better understand the exact way stream changes are manifested due to nitrogen and phosphorus pollution. We wanted to understand the relationship between these changes and stream

beneficial uses (Montana Department of Environmental Quality, 2010a)¹⁶. In summer 2010 soluble nitrogen and phosphorus were added to a reach (High Dose reach) of the stream, and major changes occurred as a result. One of the most interesting findings was the temporal manner in which stream dissolved oxygen (DO) problems occurred, and the relationship of those DO levels to measured benthic algae levels.

After nutrient additions began in early August 2010 and then continued throughout summer 2010, DO standards that protect fish (1 Day minima in DEQ-7;(Montana Department of Environmental Quality, 2010b)) were never exceeded — nor even approached — in the High Dose reach. This was true in spite of large daily DO swings (**Figure B1-2**)¹⁷. Relative to the upstream Control reach, DO increased dramatically during the day, but did not at night fall much below the Control reach values (**Figure B1-2**). Benthic algal production (growth) exceeded respiration throughout most of the summer and this, in conjunction with adequate re-aeration due to the stream's flow, likely prevented nighttime DO levels from dropping below the DO standards. However, in fall, the growing season's accumulated algal growth began to senesce en masse and we observed large amounts of decaying algae on the stream bottom in early October. The decaying algae induced a high oxygen demand which was concentrated near the bottom, in affect acting like a sediment oxygen demand (SOD), and which in turn led to exceedances of the DO standards. (The YSI in **Figure B1-2** was monitoring DO about 20 cm off the stream bottom, in a run.) The DO standards exceedances all occurred late in the season, after robust benthic algae growth had ended.

It should be noted that two other YSIs (one deployed upstream and another further downstream of the one in **Figure B1-2**, thus bracketing the High Dose reach) simultaneously recorded DO concentrations, none of which violated DO standards, even in October (data not shown). This was apparently due to longitudinal changes in stream morphology (e.g., width/depth relationships) and their affect on stream re-aeration, and dead algae accumulation on the bottom. We calculated that for DO to decline from what was measured by the YSI just upstream of the High Dose reach to that recorded in early October in **Figure B1-2** would require a SOD higher than any we could locate in the literature¹⁸. This suggests that DO concentrations were not uniform from stream surface to bottom, but rather, a bottom-to-surface DO gradient likely existed. Our analyses further indicated that DO was probably near zero near the bottom, and then near saturation at the surface. These findings suggest that DO problems of this nature can be both longitudinally and vertically patchy along the stream channel.

¹⁶ Although this study was carried out in a C-3 warm water fishery stream, the stream's key characteristics relative to algal growth make it a reasonable comparison to western Montana gravel-bottom streams, as we have done here. The stream has a gravel dominated substrate, perennial flow of about 4-6 CFS in summer, a water surface slope of 0.4%, and riffles are common throughout, as are pools. The dominant filamentous algae that grew during the study was *Cladophora*, which is also commonly found in western MT streams.

¹⁷ Routine QC checks of the instrument, including mid-project calibration, routine instrument cleaning, etc. was undertaken. The low DO values measured are considered valid measurements.

¹⁸ Stream water biochemical oxygen demand (BOD) samples were also collected in early October at the site. They were non-detect, thus the DO consumption had to be coming from the decaying algal material on the bottom.

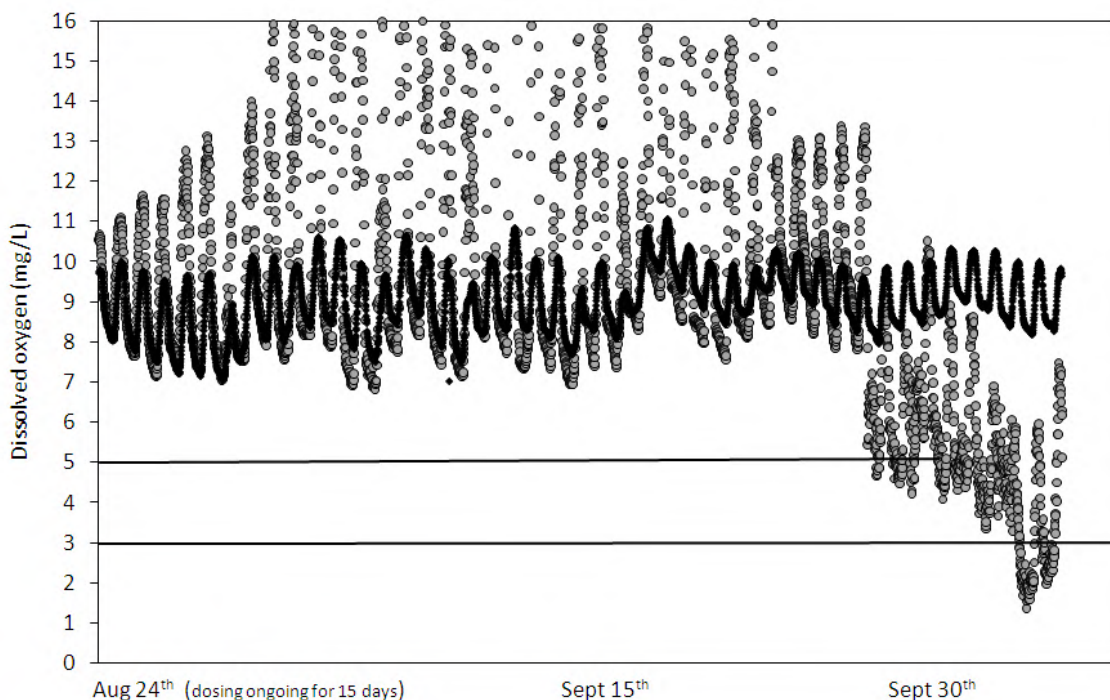


Figure B1-2. Temporal Changes in Dissolved Oxygen (DO) Levels in the High Dose Study Reach as Measured by Deployed YSI Instrument, 2010. Gray dots are DO observations at the High Dose Reach, collected at 15 min intervals. For comparison, the black line oscillating around 9 mg/L is the DO measured by another YSI in the upstream Control reach, which did not receive nutrient additions. The horizontal black lines are (upper) the adult fish and (lower) juvenile fish DO standards for this stream.

Returning to the High Dose reach's benthic-algal growth, benthic algae Chl *a* levels at the end of the growing season reached 127 mg Chl *a*/m² (Table B1-1). It is apparent from Figure B1-2 that this level of benthic algae was sufficient to induce DO violations along the channel when the algae died and decomposed en masse. The implication of this finding is that the late-season average benthic algae we measured (127 mg Chl *a*/m²) has the potential, in wadeable streams, to cause DO standards exceedances in the post-summer period, probably in late September or October. Although this study was carried out in a C-3 warm water fishery stream, the stream's late season water temperatures (which ranged from about 12-16 °C) are comparable to what is observed in typical western Montana gravel bottom streams at that time of the year. While it is true that water temperature strongly affects DO concentration, we would not expect western Montana streams manifesting similar algal densities to be able to compensate (i.e., maintain DO above standards) due to their having cooler water temperatures, as their temperatures are often about the same at that time of the year.

Table B1-1. Benthic Algae Density Measured at the High Dose Study Site, 2010

Sampling Date	Reach average benthic-algae density (mg Chl <i>a</i> /m ²)	Chl <i>a</i> replicates' CV(%)*	Reach average AFDW density (g/m ²)	AFDW replicates' CV(%)*
August 26, 2010	111	123	26	93
September 8, 2010	116	97	34	45
September 22, 2010	87	82	37	61
October 6, 2010	127	90	33	73

* 11 replicates were collected for each sampling event. Less than 11 were used to calculate reach average AFDW because core samples, if collected, are not included in the calculation of average reachwide AFDW density.

As mention at the beginning of **Section B.1**, there is a definable level of uncertainty around any given benthic Chl *a* average, but there is no way to know if the values in **Table B1-1** are at the low end, high end, or in the middle of that range. We'll assume here that the 127 mg Chl *a*/m² measured is, in fact, accurate. Thus, to be protective and assure that DO problems that could harm fish and associated aquatic life are prevented from occurring, we recommend that when a site's average benthic Chl *a* exceeds **120 mg Chl *a*/m²** it is too high, and should therefore be considered an impact to fish and associated aquatic life.

B.1.3 BENTHIC ALGAL AFDW LEVELS AND HARM-TO-USE THRESHOLDS

Ash Free Dry Weight (AFDW) collected from natural stream-sediment surfaces is a useful measurement for estimating algal biomass. The laboratory method basically oxidizes and reports back the mass of all organic material in the sample (American Public Health Association, 1998). It is useful in that it provides an additional means of assessing accumulated algal biomass independent of Chl *a*. Chl *a* levels tend to be highest during peak growth, and then decline later as the Chl *a* molecules degrade as the algae senesce (Stevenson, et al., 1996). If an assessor samples a stream late in the season, they may find fairly low Chl *a* values in spite of the presence of a large biovolume of algal material. Thus, a site that may truly have an excess algae problem could potentially be assessed as unimpaired simply due to the fact that the samples were collected late in the season.

For this reason, we recommend that AFDW be determined for all samples when Chl *a* is collected. AFDW can be determined from the same sample in a subsequent analysis that follows the Chl *a* analysis Site average. AFDW can be determined from individual replicates, or as a weighted average.

Note: AFDW results from core samples should never be included in determining a site's average AFDW. The method measures organic material from the entire core sample, not just the surface where the algae are growing, and will therefore over-report AFDW.

DEQ has not collected AFDW using the 11-transect method long enough to be able to carry out the type of statistical uncertainty calculations used for Chl *a* (Appendix A of (Montana Department of Environmental Quality, 2011c). However, there are good estimates of what comprises too much algal AFDW. In Suplee et al. (2009), the threshold Chl *a* level of 150 mg/m² corresponds to 36 g AFDW/m². In New Zealand, extensive analysis of algal AFDW resulted in a recommendation of 35 g AFDW/m² as the maximum level for gravel/cobble streams, to protect recreation use (Biggs, 2000). Note in **Table B1-1** above that the late season AFDW corresponding to 127 mg Chl *a*/m² (the Chl *a* level linked to the late-season DO problems) is 33 g/m². Long-term monitoring in the Clark Fork River (1998-2009) shows that the average summer AFDW at sites that do not develop nuisance algae (i.e., they are consistently <150 mg Chl *a*/m²) ranged from 17 to 48 g AFDW/m² (mean: 27 g AFDW/m²). Given the values presented, we recommend that site average AFDW (i.e., mean of the 11 replicates collected at a site, replicates being only templates or hoops) should be no greater than **35 g AFDW/m²**. This value should be protective of both fish and aquatic life and recreation uses.

B.1.4 SOME ADDITIONAL CONSIDERATIONS REGARDING BENTHIC ALGAE SAMPLING

Recently, DEQ has instituted an economization practice that consolidates all hoop, core, or template samples from a sampling event together, so that only three (at most) Chl *a* samples need to be analyzed,

instead of eleven. While unquestionably thrifty, the ability to determine the replicates' variance has been lost. All of the Chl *a* confidence calculations discussed in **Section B.1.1** assume that a sampling event will manifest a typical replicate CV of 73%, but this is an assumption. In cases where it is very important to truly know the replicates' CV, the replicates should each be analyzed separately..

Cases may also arise where an entity is not satisfied with the level of confidence or interval widths DEQ has presented here. Collecting 11 samples in a stream reach is already a time consuming and expensive procedure, and we consider the confidence level (80%) and interval width ($\pm 30\%$ of the mean) to be satisfactory for algae sampling. If an entity (regulated or otherwise) desires higher levels of precision, then it is our recommendation that the financial cost to achieve those levels fall to the entity.

If more precision is wanted, how many more algae samples should be collected? Long term sampling of benthic Chl *a* by Dr. Vicki Watson on the Clark Fork River shows that with about 20 replicates, one can be 90% confident that the measured average Chl *a* is within $\pm 20\%$ of the true average. For benthic algae sampling, which is inherently noisy, this is a fairly high degree of confidence. For DEQ's wadeable stream method, this would involve placing 20 transects instead of 11 along a site, with algae collection occurring at each of the 20 transects using the systematic approach (R, L, C, repeat) described in the SOP.

B.2 ASSESSMENT USING BIOMETRICS

DEQ has used diatom-algae assemblages and macroinvertebrate assemblages for many years to make assessment of stream water quality and condition. Some of these metrics are being incorporated into the process for assessing excess nitrogen and phosphorus pollution. Details of each are given in the **Sections B.2.1** and **B.2.2** below.

B.2.1 BIOMETRICS BASED ON DIATOM ALGAE

DEQ has been using benthic diatoms to assess water quality since the 1970s. Earlier approaches used diagnostic and descriptive biometrics based on quasi-universal ecological attributes of diatom species and observed structural characteristics of benthic diatom associations (Bahls, et al., 2008). The current approach (initiated in 2004) uses regional classification, stream reference sites, a priori knowledge of stressors in streams, and discriminant function analysis to identify "increaser" taxa that respond to specific stressors and in a predictable way (Teply and Bahls, 2006; Bahls, et al., 2008; Teply and Bahls, 2005). The metrics were specifically developed to indicate the likelihood of nitrogen and phosphorus impairment, have been developed for many regions of the state, and can function properly in the presence of other major pollutants (Teply, 2010a; Teply, 2010b). Please see the periphyton SOP (Montana Department of Environmental Quality, 2011b) for details. Each sample will provide the probability of a nutrient problem, such as in this example:

This indicates that the sample represents a stream that has about a 65% percent probability of being impaired due to nutrients (nitrogen or phosphorus) under 303(d) guidelines. This probability is based on past evidence of taxa associated with nutrient-impaired streams in the Northern/Canadian Rockies Stream Group. Nutrient Increaser Taxa do not discriminate other causes of impairment and this result does not

indicate whether the stream may or may not be impaired due to other causes.

Diatom nutrient-increaser metrics are available for the Northern and Canadian Rockies ecoregions, the Idaho Batholith ecoregion, and a series of level-IV ecoregions that predominate along the Rocky Mountain Front (i.e., mountain-to-plains transitional zones). **Note: There is currently no validated nutrient-increaser model for use in the Middle Rockies ecoregion.** As of this writing, a sample that indicates >51% probability of impairment by nutrients should be considered to indicate the sample is from a site with excess nutrient problems. Findings based on diatom samples are not, however, stand alone, and need to be incorporated with other data per the decision framework described in **Section 3.0** of the main document.

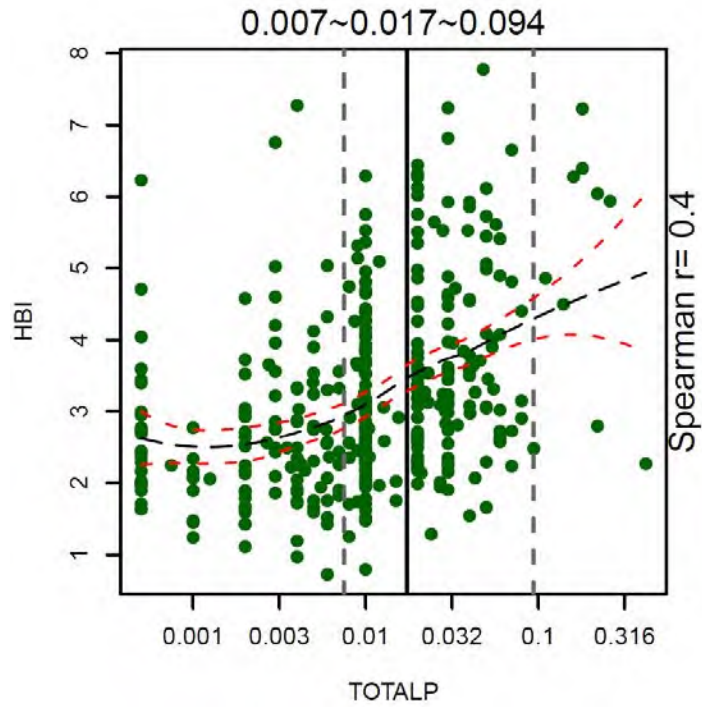
B.2.2 BIOMETRICS BASED ON MACROINVERTEBRATES

Benthic macroinvertebrates have been used for a long time as indicators of stream water quality (e.g., (Hilsenhoff, 1987; Barbour, et al., 1999). Recently, DEQ and EPA carried out a correlation analysis using Montana data to examine the relationship between stream nutrient concentrations and benthic macroinvertebrate metrics (Tetra Tech Inc., 2010). Among the metrics, one (Hilsenhoff Biotic Index, or HBI) is sufficiently well understood and showed a sufficiently patterned response to stream nutrient gradients in Montana’s mountainous regions that we believe it can be used as a secondary response variable to help assess nutrient impacts. How the metric will be incorporated with other effect variables was discussed in **Section 3.0**. We here define a biological threshold for the HBI metric, giving consideration to the fact that almost all mountainous streams in Montana are to be maintained suitable for “growth and propagation of salmonid fishes and associated aquatic life” (A-Closed, A-1, B-1, C-1 classes), or “growth and marginal propagation of salmonid fishes and associated aquatic life” (B-2, C-2 classes).

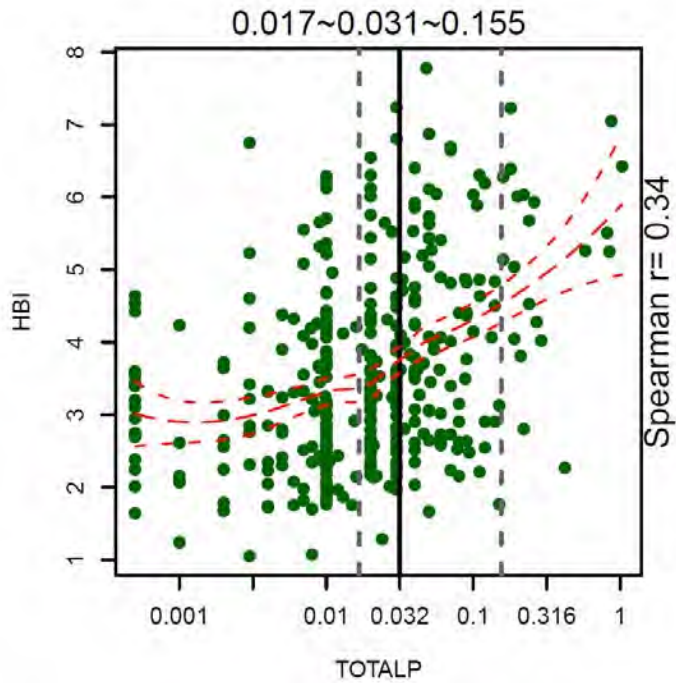
B.2.2.1 Hilsenhoff Biotic Index

HBI is based on tolerance values. A large number of macroinvertebrate taxa have been assigned a numeric value which represents the organism’s tolerance to organic pollution (Barbour et al., 1999). HBI is then calculated as a weighted average tolerance value of all individuals in a sample. Higher index values indicate increasing tolerance to pollution.

Figure B2-1(A) shows the HBI vs. TP correlation in mountainous-region streams (Tetra Tech Inc., 2010). The data are from the “Mountains” site class (a.k.a. Mountains bioregion)(Montana Department of Environmental Quality, 2006). The Mountains Bioregion comprises stream sites whose catchments are mainly in the Middle Rockies, Canadian Rockies, Northern Rockies, and Idaho Batholith ecoregions and where elevation is greater than 1700 m, precipitation is greater than 700 mm/year, and annual mean daily maximum temperature is < 11°C. Also shown is the same data, but this time aggregated simply by level III ecoregion rather than bioregion (**Figure B2-1(B)**); note the very similar patterns. This indicates that ecoregions and bioregions work about equally well as geospatial frameworks to segregate macroinvertebrate data for the purpose of correlation to stream nutrient concentrations.



A. Mountains bioregion.



B Middle Rockies ecoregion.

Figure B2-1. HBI metric vs. TP.

The relationship between HBI and TN is shown below (**Figure B2-2**), aggregated by ecoregions (only Middle Rockies ecoregion shown). As for TP vs. HBI, there is a noisy but discernable (and significant) relationship between nutrients and the HBI score.

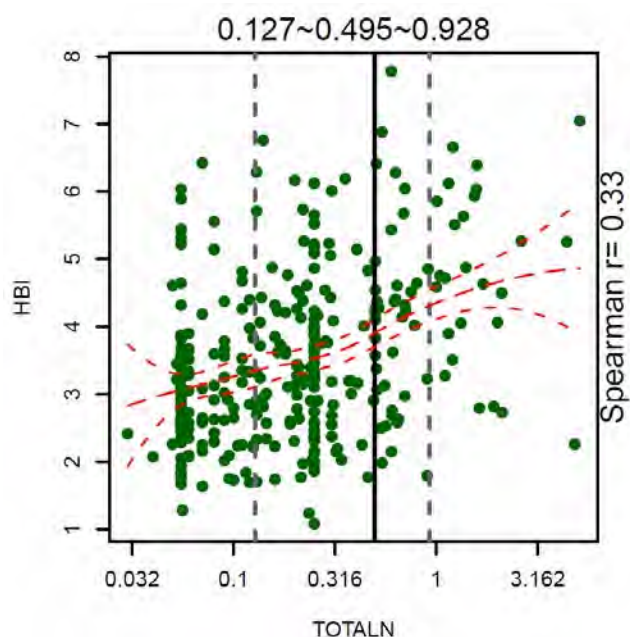


Figure B2-2. HBI Macroinvertebrate Metric vs. Stream TN Concentration Data are aggregated by ecoregions (Middle Rockies ecoregion shown).

Several components of **Figures B2-1 (A) and (B)** and **Figure B2-2** require explanation. Change-point analysis (Qian, et al., 2003) shows the statistically-derived point in the dataset where a shift, or threshold, in Y has occurred relative to X. In the figures, it is the vertical black line, bracketed to the right and left by its 90% confidence interval as dashed grey lines. This change-point, \pm its 90% confidence interval, is shown as a numeric value at the top of each figure. The curving dashed lines running left to right are the locally-weighted regression line (LOWESS) and associated 90% confidence limit as dashed red lines. The Spearman's *rho* correlation value (Conover, 1999) between nutrient and metric is shown on the right side of each figure.

B.2.2.2 Interpreting the Macroinvertebrate Metric Correlations to Nutrients

Although **Figure B2-1** and **Figure B2-2** demonstrate significant correlations (parametric least-squares regression), they show large amounts of scatter. Numerous factors contribute to this scatter. For example, macroinvertebrates are separated from the direct effects of nutrient increases by one trophic level (i.e., nutrients directly influence aquatic plants and algae, and changes in plant species and biomass in turn influences macroinvertebrates). This is why they are considered secondary data, per the **Section 3.0** decision framework. In addition, environmental factors (natural and human-caused) other than nutrients influence macroinvertebrate populations, adding to the scatter in the relationships between the metrics and the nutrients. This is especially true for these data, which have been compiled over relatively large spatial areas and incorporate many different streams sampled over a long period of time (> 15 years). In spite of the scatter, there are patterns that can be discerned. Note, for example, that when TP is greater than 0.15 mg/L in **Figure B2-1(B)**, the likelihood of a stream having an HBI score <4 is very low.

The following section provides more detail on how **Figure B2-1** and **Figure B2-2** (and related data) were used to interpret the macroinvertebrate metrics relative to nutrients.

B.2.2.3 Patterns Observed Between HBI and Change-points, and Previously Used DEQ Thresholds

DEQ has in the past used thresholds for stream impairment using the HBI metric (Bukantis, 1998). Mountainous and intermountain valley regions used HBI values of 3.0 and 4.0, respectively, as the threshold values between full support and impairment of aquatic life (Bukantis, 1998). Hilsenhoff (1987) notes that the transition between Very Good water quality (slight organic pollution) and Good water quality (some organic pollution) is an HBI score of 4.5. How do the thresholds relate to the data seen in **Figures B2-1** and **Figure B2-2**? Results are shown below in **Table B2-1**, and include data from the Middle Rockies, the Mountains Bioregion, and the Low Valleys Bioregion.

Table B2-1. Nutrient Concentrations on the LOWESS Regression Line Corresponding to Specified Thresholds.

(Statistical Changepoint or Macroinvertebrate Metric Value) for **Figures B2-1, B2-2**, and Similar Graphs. Data are grouped by bioregions and ecoregions. Only Middle Rockies ecoregion shown due to insufficient data on other ecoregions.

MT Bioregion	Parameter	Metric Threshold Value	Corresponding Nutrient Concentration	
			TP (mg/L)	TN (mg/l)
Mountains bioregion	Changepoint		0.02	0.46
Mountains bioregion	HBI	4.0	0.07	1.15
Mountains bioregion	HBI	4.5	0.19	beyond graph
Low Valleys bioregion	Changepoint		0.04	0.32
Low Valleys bioregion	HBI	4.0	0.04	0.32
Low Valleys bioregion	HBI	4.5	0.19	1.35
Middle Rockies Ecoregion	Changepoint		0.03	0.50
Middle Rockies Ecoregion	HBI	4.0	0.04	0.55
Middle Rockies Ecoregion	HBI	4.5	0.16	1.7

One observation that can be made about **Table B2-1** is that, in any given region, HBI scores of 4.5 can correspond to nutrient concentrations much higher than the corresponding changepoint concentrations, whereas nutrient concentrations matching an HBI of 4.0 usually match fairly closely to the changepoint concentrations. These results suggest that an HBI score of 4.0 is a meaningful threshold relative to stream nutrient concentrations in western Montana streams. This conclusion stems from the fact that an HBI of 4.0 has previously been recommended as a threshold by DEQ for this region (Bukantis 1998), and that the data show a statistically-significant threshold (i.e., a change in biological structure relative to nutrients) at an HBI of 4.0. An HBI score of 4.0 is also meaningful from the perspective of water quality protection, as scores of 4.5 indicates transition into conditions where some organic pollution is already noted (Hilsenhoff, 1987). Thus, if elevated nutrients are suspected and an HBI score of >4 is encountered, there is a good chance that excess nutrients are causing the problem.

APPENDIX C. DETAILS ON ASSESSMENT METHODOLOGIES FOR WADEABLE PLAINS STREAMS

Benthic algae levels discussed in **Appendix B, Section B.1.1** are appropriate for the mountainous and transitional (mountain-to-plains) region of the western part of the state. Many eastern Montana plains streams are ecologically different from western Montana streams, and therefore the results from the public perception algae survey (Suplee et al., 2009) should probably not be universally applied to them. Montana plains streams often become intermittent, are generally low gradient, commonly have mud bottoms and are often turbid, and frequently have substantial macrophyte populations. It is not uncommon in these streams to see macrophytes intermixed with filamentous algae and floating masses of green algae; these conditions are even occasionally observed in plains streams minimally impacted by people (i.e., plains reference streams). These situations make measurement of benthic algal biomass in plains streams difficult and complicated. Further, our analysis shows that 4% of the sampling-event averages from plains reference streams have benthic algae $>150 \text{ mg Chl } a/\text{m}^2$, whereas none of the sampling-event averages for benthic algae in western Montana reference streams even approach this value (e.g., the highest sampling-event average for a western Montana reference site was $76 \text{ mg Chl } a/\text{m}^2$). These findings, taken together, suggest that benthic algae measurement is probably not the best assessment tool for determining impairment for plains region streams. As such, we recommend that benthic algal biomass not be used to assess plains streams.

The following sections discuss the assessment tools we believe are more appropriate for assessing wadeable streams of the plains region.

C.1.0 ASSESSMENT USING DIATOM ALGAE BIOMETRICS

Nutrient-increaser diatom metrics have been developed for plains wadeable streams using the same methods as the diatom metrics presented in **Appendix B**. The metrics will indicate the likelihood of nitrogen and phosphorus impairment, and can function properly in the presence of other common pollutants such as sediment and metals (Teply, 2010a; Teply, 2010b). Please see DEQ's periphyton SOP (Montana Department of Environmental Quality, 2011b) for details. Each periphyton sample will provide the probability of a nutrient problem, such as in this example:

This indicates that the sample represents a stream that has about a 25% percent probability of being impaired due to nutrients (nitrogen or phosphorus) under 303(d) guidelines. This probability is based on past evidence of taxa associated with nutrient-impaired streams in the Warm-water Stream Group. Nutrient Increaser Taxa do not discriminate other causes of impairment and this result does not indicate whether the stream may or may not be impaired due to other causes.

As of this writing, a sample that indicates **>51%** probability of impairment by nutrients should be considered to indicate the sample is from a site with excess nutrient problems. Findings based on diatom samples are not, however, stand alone, and need to be incorporated with other data per the decision framework described in **Section 3.0** of the main document.

C.2.0 ASSESSMENT USING THE DIFFERENCE BETWEEN THE DAILY MAXIMUM DISSOLVED OXYGEN CONCENTRATION AND THE DAILY MINIMUM DISSOLVED OXYGEN CONCENTRATION (DELTA)

We initially considered using DEQ's DO standards for routine assessment of plains streams. But examination of long-term DO datasets, including those from the plains-stream dosing study (**Appendix B, Section B.1.2**), showed that DO standards are a fairly insensitive way to assess nutrient impacts in plains streams. We found only a low number of instances where streams that we know have excess nutrient impacts consistently violated the DO standards, and some nutrient-impacted stream sites never violated the DO standards at all (at least during summer and early fall).

We found that streams that have high daily DO **delta** (i.e., the daily maximum DO minus the daily minimum DO) may *eventually* manifest DO standards violations late in the year, when the algae die and decompose en masse (see **Appendix B, Section B.1.2**). To address this, the DO monitoring-period could be extended (e.g., to the end of October or early November), but this is not always practical given the unpredictable onset of winter and its affect on road access, retrieval of deployed instruments, etc. In lieu of extending the monitoring season, measurement of summer and early fall DO deltas has great potential as an assessment tool. Others have found that DO delta is related to harm to aquatic life. In Minnesota, strong positive correlations are found between the percent tolerant fish and the magnitude of the DO deltas. At DO deltas <4.5 mg/L, tolerant fish are usually <10% of the total fish population, but when DO deltas are > 4.5 mg/L tolerant fish become a substantial proportion of the population. Conversely, sensitive fish exhibit a wide range of values at DO deltas <4 mg/L, but above 4.5 mg/L they decline to 10% or less of the fish population (Minnesota Pollution Control Agency, 2010). The state of Minnesota is recommending that, for the northern plains regions at its southern end, measured DO deltas should not exceed 5.0 mg/L.

DO delta is also shown to be lower in reference streams. In Tennessee, the maximum DO delta value reported in a wadeable reference stream is 4.0 mg/L, whereas about 45% of impacted streams assessed have measured DO deltas greater than 4.0 mg/L (Arnwine and Sparks, 2003).

We calculated DO deltas for Montana plains reference streams. There were a total of 177 day's worth of delta values from the Box Elder Creek Control reach (Montana Department of Environmental Quality, 2010a) and the Little Beaver Creek Reference Site, collected in 2009 and 2010. 90% of the daily DO deltas from these reference sites were less than 5.3 mg/L. The single highest DO delta measured was 6.6 mg/L, from Little Beaver Cr, which is influenced by the presence of macrophytes. (Also, on about 10% of occasions, DO at the Little Beaver Cr reference site dropped just below the juvenile fish standard of 5.0 mg DO/L; however, it never got close to the adult fish DO standard of 3.0 mg/L.)

No fish data were collected contemporaneously with the reference site DO data, however fish populations have been evaluated in both of these streams (Bramblett, et al., 2005) at alternative reference sites (BoxElder_382_W and LittleBe_410_W) not far downstream. These alternative reference sites had among their fish populations substantial proportions of sensitive/intolerant species, especially Box Elder Creek in the Little Beaver Creek site 17% of the fish captured were considered sensitive/intolerant. Sensitive/intolerant species are typically the first species to disappear due to chemical and physical perturbations (e.g., low DO) (Barbour, et al., 1999). Assuming DO patterns at the alternative reference sites are roughly comparable to those which we monitored, the fish data suggest

that a healthy fishery is being maintained in spite of occasionally high DO deltas and occasional exceedances of the juvenile fish criterion¹⁹.

We employed change-point analysis (Qian, et al., 2003) to help identify any DO delta thresholds. We had 11 plains-stream locations, in both reference (Suplee, et al., 2005) and non-reference condition, which had continuous instrument-measured DO data (**Table C2-1**). These sites comprised both perennial and intermittent streams. Delta values were calculated, resulting in over 550 days of DO delta values. Each location was assigned a rating (1 through 4) representing our BPJ assessment of how strongly it was impacted by nutrients, and these ratings were associated with the corresponding DO delta values. The ratings used were: 1 = no known nutrient impact; 2 = low nutrient impact; 3 = medium nutrient impact; 4 = high nutrient impact. In quite a few cases the ratings could be very accurately assigned, as some sites were reference sites and some were part of the nutrient dosing study (e.g., all DO deltas associated with the High-dose reach were assigned a rating of 4). Change-point analysis was then run on the dataset with delta values on the X axis and their corresponding rating scores on the Y. A highly significant ($p < 0.001$) change-point was identified at 6.0 mg/L (the 90% confidence interval for the change-point was 5.5 mg/L to 6.6 mg/L). Essentially, analysis showed that in moving from sites rated 3 to sites rated 4, the magnitude of the DO deltas ramped up dramatically, with the threshold of this change occurring at 6.0 mg/L.

Table C2-1. Long-term DO Monitoring Sites in Plains Streams

Station ID	Continuous Data Time Range	DO observations time-step (min)
Y26BOXEC08-upstream	Aug 25 to Sept 30, 2010	15
Y26BOXEC08-downstream	Aug 24 to Sept 30, 2010	15
Y26BOXEC04	July 26 to Sept 26, 2009 <u>AND</u> July 19 to Oct 7, 2010	15
Y26BOXEC09-upstream	Aug 25 to Sept 30, 2010	15
Y26BOXEC09-downstream	Aug 11 to Sept 30, 2010	15
Y27LBVRC02	Aug 30 to Sept 25, 2008 <u>AND</u> Aug 29 to Oct 8, 2010	15
Y27LBVRC04	Aug 30 to Sept 24, 2008 <u>AND</u> July 29 to Oct 8, 2010	15
M22CTWDC03	July 22 to July 24, 2003	30
M22BSPRC10	Aug 17 to Aug 20, 2003	30
Y27LBVRC12	Aug 30 to Sept 25, 2008	15
Y27LBVRC01	July 28 to Sept 24, 2009	15

We then estimated false-positive and false-negative rates, and made comparisons to the reference data, using the datasets above. Data were aggregated to create two basic groups (ratings 1, 2 = nutrient un-impacted; ratings 3, 4 = nutrient impacted), and 65 observations were then randomly drawn for false positive/negative analysis (35 from the un-impacted group, 30 from impacted group). Results are shown in **C2-2** below.

¹⁹ Dr. Robert Bramblett (MSU fishery biologist; personal communication, March 11, 2010) provided species counts and IBI scores for the two sites. Box Elder Creek's score was quite good (77). Dr. Bramblett noted that the Little Beaver Creek site's IBI was being reduced (score 55) by the presence of northern pike; this non-native predatory fish plays a large role in reducing metric scores in the Bramblett IBI. He noted that the site's habitat was simple and northern pike were crowded in with their prey, but otherwise, the Little Beaver Creek site seemed healthy.

Table C2-2. Statistics Associated with DO Delta Threshold

DO Delta Threshold	% of all reference-site deltas > threshold	Estimated false positive rate*	Estimated false negative rate†
≥ 6.0	3%	9%	77%
≥ 5.3	10%	23%	63%
≥ 5.0	15%	26%	60%
≥ 4.0	26%	54%	53%

* The probability that a truly un-impacted site is found to have a DO delta value great than the threshold.

† The probability that a truly impacted site is found to have a DO delta value less than the threshold

The change-point threshold (DO delta of 6.0 mg/L) is probably too high for assessment, as it has a particularly high false-negative rate (77%; **Table C2-2**). Other DO thresholds between 6.0 and 4.0 mg/L were also evaluated. A DO delta threshold of 4.0 mg/L provides good balance between alpha and beta error, but its ability to determine impact is no better than a coin flip. It also allows far too many of the deltas from the reference sites to be exceedances (in fact, almost all observations from one reference site are >4.0 mg/L). The reality is, sites with excess nutrient problems do not manifest high DO deltas every single day throughout the summer, due to the vagaries of clouds, weather, and wind, which means that as an assessment tool DO delta will inherently have high false-negative rates. We selected 5.3 mg/L as the threshold for these reasons:

- It has false positive and negative rates comparable to what was found for the diatom-based nutrient increaser metrics applicable to this region(Teply, 2010b)
- It is very close to the lower bound of the 90% confidence interval (i.e., DO delta of 5.5 mg/L) of the change-point, as determined from the change-point analysis
- It keeps the proportion of reference-site data exceeding the threshold to no more than 10%
- It is in fairly good agreement with the threshold recommended by Minnesota for their plains region (i.e., DO delta of 5.0 mg/L)to protect fish and aquatic life

C.2.1 INSTANTANEOUS DO MONITORING IN WADEABLE PLAINS STREAMS

DEQ assessment can continue to rely on instantaneous measurements of DO. The following guidelines are recommended for instantaneous DO data collection.

When to Measure, Minimum: Without question the best time to measure the lowest daily DO is at dawn. DO in streams and standing waters is usually at its daily low just before sunrise (e.g., (Odum, 1956; Teply, 2010b; Boyd, et al., 1978; Madenjian, et al., 1987; Quinn and Gilliland, 1989). DO measurements in streams at other times of the day usually cannot give a reliable estimation of the nighttime low, especially in plains streams, because numerous other factors (e.g., wind speed and direction, air temperature, the stream’s sediment oxygen demand, presence/absence of aquatic macrophytes) play a role in the rate of DO decline per unit time. Simple models incorporating various environmental factors have been used to estimate dawn DO in aquaculture ponds (e.g., (Boyd, et al., 1978; Madenjian, et al., 1987), and more sophisticated models can simulate diel DO cycles in streams and rivers (e.g., QUAL2K; (Chapra, et al., 2008). However, numerous input variables are required to run these models, making these impractical approaches for routine stream DO assessment. Therefore, we recommend dawn DO measurements be taken. We examined a number of plains stream diel DO plots, including both reference and non-reference sites, and found that **the most appropriate time window for capturing the DO daily minima is between dawn (or pre-dawn) and 8:00 am**. This time frame should be adhered to when sampling during the summer growing season (June 16th to September 30th).

The assessor should make notes of weather conditions at the time (approximate wind speed and direction, cloud cover).

When to Measure, Maximum: The DO concentration maximum in flowing streams usually occur after solar noon, commonly around 4:00 pm. The combined effects of plant/algae respiration, plant/algae primary production (which peaks around solar noon), and flow and re-aeration influences on DO saturation result in the typical sinusoidal DO patterns observed each day (Odum, 1956; Chapra and Di Toro, 1991). We examined the continuous recordings of DO for plains stream (both flowing and intermittent), and found that most daily DO peaks occurred between 2:30 pm and 5:00 pm. Time of year appeared to have no discernable effect, and the exact timing of the DO peak seemed more influenced by local factors (probably clouds, and wind velocity and direction). **We recommend that monitoring for the DO maximum occur between 2:30 pm and 5:00 pm.** Measurements need not be taken continuously during that period; checking stream DO every 15-30 minutes should be sufficient to catch the peak. You may need to stay somewhat beyond 5:00 pm if the values are still climbing. DEQ's main hand-held instrument for DO measurement is the YSI 85. This instrument has a 50 reading, manual-entry memory which can be used for collecting daily DO maximums. Set the instrument up in situ and then leave it on between 2:30 pm and 5:00 pm; record readings every 15-30 minutes by depressing the ENTER button for two seconds. Data may be downloaded later.

For the purpose of calculating DO delta, at least 3 DO sampling events should be taken in each assessment reach. Temporal independence of DO measurements is not a concern, since DO delta can be quite variable on a day-to-day basis. Each sampling event DO delta can be considered on its own merits. Therefore, there is no reason to wait for 30 days to collect a subsequent DO measurement at a site. The assessor may collect DO data each day while they are in the area. This will also help increase the number of sampling events collected from an assessment reach.

C.3.0 BIOCHEMICAL OXYGEN DEMAND

Biochemical oxygen demand is one of the oldest water quality assessment tools, first recommended for use by the English Royal Commission on Sewage Disposal in the early 1900s (Hynes, 1966). It is a standardized test carried out over 5 days that measures the amount of putrescible material in water, which consumes oxygen as it decomposes. It is also one of the required measurements for wastewater nationally under the National Secondary Treatment Regulations (40 CFR part 133).

Montana has no standard for ambient BOD₅ in streams (although wastewater facility effluent and mixing zones are held to BOD₅ requirements). Nevertheless, the following guidelines for BOD₅ are commonly followed in many parts of the world:

- 1-2 mg BOD₅/L: Very clean water, little biodegradable waste
- 3-5 mg BOD₅/L: Moderately clean water, some biodegradable waste
- 6-9 mg BOD₅/L: Many bacteria, much biodegradable matter
- ≥10 mg BOD₅/L: Very bad, large amounts of biodegradable wastes in the water

The method used at the DPHHS Environmental Laboratory currently has a detection limit of 4 mg BOD₅/L (which coincides with the Royal Commission's recommendation that 4 mg BOD₅/L not be exceeded; Hynes, 1966). In plains streams we have found that otherwise healthy streams (i.e., reference sites) can have values in the 6-9 range fairly often. We recommend a value of 8.0 mg/L as a threshold for concern in plains streams.

APPENDIX D - REFERENCES

- American Public Health Association. 1998. Standard Methods for the Examination of Water and Wastewater. L. S. Clesceri, A. E. Greenberg, and A. D. Eaton (Eds.), 20th ed., Washington, DC: American Public Health Association.
- Arnwine, D. H. and K. J. Sparks. 2003. Comparison of Nutrient Levels, Periphyton Densities and Diurnal Dissolved Oxygen Patterns in Impaired and Reference Quality Streams in Tennessee. Nashville, Tennessee: Tennessee Department of Environment and Conservation, Division of Water Pollution Control.
- Bahls, Loren L., M. Tepley, Rosie Sada de Suplee, and Michael W. Suplee. 2008. Diatom Biocriteria Development and Water Quality Assessment in Montana: A Brief History and Status Report. *Diatom Research*. 23(2): 533-540.
- Barbour, Michael T., Jeroen Gerritsen, Blaine D. Snyder, and James B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish: Second Edition. Washington, DC: United States Department of Environmental Protection, Office of Water. Report EPA 841-B-99-002.
- Biggs, B. J. F. 2000. New Zealand Periphyton Guideline: Detecting, Monitoring and Managing Enrichment of Streams, Christchurch, New Zealand: NIWA. <http://www.mfe.govt.nz/publications/water/nz-periphyton-guide-june00.html>.
- Boyd, C. E., R. P. Romaine, and E. Johnston. 1978. Predicting Early Morning Dissolved Oxygen Concentrations in Channel Catfish Ponds. *Transactions of the American Fisheries Society*. 107: 484-492.
- Bramblett, Robert G., Thomas R. Johnson, Alexander V. Zale, and Daniel Heggem. 2005. Development and Evaluation of a Fish Assemblage Index of Biotic Integrity for Northwestern Great Plains Streams. *Transactions of the American Fisheries Society*. 134(3): 624-640.
- Bukantis, Robert T. 1998. Rapid Bioassessment Macroinvertebrate Protocols: Sampling and Sample Analysis SOPs: Working Draft. Helena, MT: Montana Department of Environmental Quality.
- California Environmental Protection Agency State Water Resources Control Board. 2004. Functional Equivalent Document, Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List - Final.
- Chapra, Steven C. and D. M. Di Toro. 1991. Delta Method for Estimating Primary Production, Respiration, and Reaeration in Streams. *Journal of Environmental Engineering*. 117(5): 640-655.

- Chapra, Steven C., Gregory J. Pelletier, and Hua Tao. 2008. A Modeling Framework for Simulating River and Stream Water Quality, Version 2.1: Documentaion and Users Manual. Medford, MA: Civil and Environmental Engineering Department, Tufts University.
- Cochran, W. G. 1977. Sampling Techniques, 3rd ed., New York: John Wiley and Sons.
- Conover, W. J. 1999. Practical Nonparametric Statistics, 3rd. ed., New York: John Wiley & Sons.
- Cormier, Susan, Susan Braen Norton, Glen W. Suter, II, and Donna K. Reed-Judkins. 2000. Stressor Identification Guidance Document. Washington, D.C.: U.S. Environmental Protection Agency, Office of Water, Office of Research and Development. Report EPA 822-B-00-025.
- Cormier, Susan and G. W. Suter, II. 2008. A Framework for Fully Integrating Environmental Assessment. *Environmental Management*. 42: 543-556.
- DiTomaso, J. M. and E. A. Healy. 2003. Aquatic and Riparian Weeds of the West. Oakland, CA: University of California Agriculture and Natural Resources. Report 3421.
- Dodds, Walter K., V. H. Smith, and Bruce Zander. 1997. Developing Nutrient Targets to Control Benthic Chlorophyll Levels in Streams: A Case Study of the Clark Fork River. *Water Resources*. Vol. 31(no. 7): 1738-1750.
- Droop, M. R. 1973. Some Thoughts on Nutrient Limitation in Algae. *Journal of Phycology*. 9: 264-272.
- Elrifi, I. R. and D. H. Turpin. 1985. Steady-State Luxury Consumption and the Concept of Optimum Nutrient Ratios: A Study With Phosphate and Nitrate Limited *Selenastrum Minutum* (Chlorophyta). *Journal of Phycology*. 21: 592-602.
- Environmental Research Laboratory-Duluth. 1997. Guidelines for Preparation of the Comprehensive State Water Quality Assessments (305(b) Reports) and Electronic Updates: Supplement. Washington, DC: Assessment and Watershed Protection Division, Office of Wetlands, Oceans, and Watershed, Office of Water, U.S. Environmental Protection Agency. Report EPA-841-B-97-002B.
- Flynn, K. and Michael W. Suplee. 2010. Defining Large Rivers in Montana Using a Wadeability Index. Helena, MT: Montana Department of Environmental Quality.
<http://deq.mt.gov/wqinfo/Standards/default.mcp>.
- Gilbert, R. O. 1987. Statistical Methods for Environmental Pollution Monitoring., New York: John Wiley & Sons, Inc.
- Hilsenhoff, W. L. 1987. An Improved Biotic Index of Organic Stream Pollution. *Great Lakes Entomologist*. 20(1): 31-39.

- Hurlbert, S. H. 1984. Pseudoreplication and the Design of Ecological Field Experiments. *Ecological Monographs*. 54: 187-211.
- Hynes, H. B. N. 1966. The Biology of Polluted Waters, 3rd ed., Liverpool: Liverpool University Press.
- Klarich, Duane A. 1982. General Characteristics of Aquatic Macrophyte Associations in the Upper Poplar River Drainage of Northeastern Montana. Billings, MT: Montana Department of Health and Environmental Sciences.
- LaVoie, I., S. Campeau, F. Darchambeau, G. Cabana, and P. J. Dillon. 2008. Are Diatoms Good Integrators of Temporal Variability in Stream Water Quality? *Freshwater Biology*. 53: 827-841.
- Lohman, K. and John C. Prisco. 1992. Physiological Indicators of Nutrient Deficiency in *Cladophora* (Chlorophyta) in the Clark Fork of the Columbia River, Montana. *Journal of Phycology*. 28: 443-448.
- Madenjian, C. P., G. L. Rogers, and A. W. Fast. 1987. Predicting Night Time Dissolved Oxygen Loss in Prawn Ponds of Hawaii: Part 1 - Evaluation of Traditional Methods. *Aquacultural Engineering*. 6: 191-208.
- Mapstone, B. D. 1995. Scalable Decision Rules for Environmental Impact Studies: Effect Size, Type I, and Type II Errors. *Ecological Applications*. 5: 401-410.
- Minnesota Pollution Control Agency. 2010. *Draft* Minnesota Nutrient Criteria Development for Rivers. Report wq-s6-08. <http://www.pca.state.mn.us/index.php/water/water-permits-and-rules/water-rulemaking/proposed-water-quality-standards-rule-revision.html>.
- Montana Department of Environmental Quality. 2005. Field Procedures Manual For Water Quality Assessment Monitoring. Helena, MT: Montana Department of Environmental Quality, Water Quality Planning Bureau. Report WQPBWQM-020.
- 2006. Sample Collection, Sorting, and Taxonomic Identification of Benthic Macroinvertebrates. Helena, MT: Montana Department of Environmental Quality. Report WQPBWQM-009.
- 2007. Sampling and Analysis Plan, and Associated White Paper: Sampling Reference Sites to Produce a More Uniform Nutrient Dataset and Improve Montana's Wadeable Stream Nutrient Criteria.
- 2010a. Box Elder Creek Nutrient Addition Study: A Project to Provide Key Information for the Development of Nutrient Criteria in Montana Prairie Streams Quality Assurance Project Plan. Helena, MT: Water Quality Planning Bureau.
- 2010b. Circular DEQ-7, Montana Numeric Water Quality Standards. Helena, MT.

- 2011a. Field Procedures Manual for Water Quality Assessment Monitoring, Draft. Helena, MT: Montana Department of Environmental Quality. Report WQPBWQM-020.v.3.
- 2011b. Periphyton Standard Operating Procedure. Helena, MT: Montana Department of Environmental Quality. Report WQPVWQM-010.
- 2011c. Sample Collection and Laboratory Analysis of Chlorophyll-*a* Standard Operation Procedure, Revision 5. Helena, MT: Montana Department of Environmental Quality. Report WQPBWQM-011.
- Montana Department of Environmental Quality, Planning, Prevention and Assistance Division. 2009. Montana 2008 Final Water Quality Integrated Report. Helena, MT: Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau. Report WQBDMSRPT-02-F.
- Muenschner, W. C. 1944. Aquatic Plants of the United States: Cornell University Press.
- Neter, John, W. Wasserman, and Michael H. Kutner. 1989. Applied Linear Regression Models, 2nd Edition ed., Homewood, IL: Irwin Press. Accessed 3/90.
- Norris, R. H. and A. Georges. 1993. "Analysis and Interpretation of Benthic Macroinvertebrate Surveys," in *Freshwater Biomonitoring and Benthic Macroinvertebrates*, Rosenberg, D. M and Resh, V. H., (New York: Chapman and Hall)
- Norris, R. H., E. P. McElravy, and V. H. Resh. 1992. "The Sampling Problem," in *The River Handbook*, Calow, P. and Petts, G. E., (Oxford, England: Blackwell Scientific Publications)
- Odum, H. T. 1956. Primary Production in Flowing Waters. *Limnology and Oceanography*. 1: 102-117.
- Osenberg, C. W., R. J. Schmitt, S. J. Holbrook, K. E. Abu-Saba, and A. R. Flegal. 1994. Detection of Environmental Impacts: Natural Variability, Effect Size, and Power Analysis. *Ecological Applications*. 4: 16-30.
- Ott, R. L. 1993. An Introduction to Statistical Methods and Data Analysis, 4th Edition ed., Belmont, CA: Duxbury Press.
- Portielje, R. and L. Lijklema. 1994. Kinetics of Luxury Uptake of Phosphate by Algae-Dominated Benthic Communities. *Hydrobiologia*. 275-276(1): 349-358.
- Qian, S. S., R. S. King, and C. J. Richardson. 2003. Two Statistical Methods for the Detection of Environmental Thresholds. *Ecological Modelling*. 166: 87-97.

- Quinn, J. M. and B. W. Gilliland. 1989. The Manawatu River Cleanup - Has It Worked? *Transactions of the Institute of Professional Engineers of New Zealand*. 16: 22-26.
- Rhee, G. Y. 1973. A Continuous Culture Study of Phosphate Uptake, Growth Rate and Polyphosphate in *Scenedesmus Sp.* *Journal of Phycology*. 9: 495-506.
- Sandgren, C. D., P. M. Engevoild, S. Neerhof, and T. J. Ehlinger. 2004. Nuisance *Cladophora* in Urban Streams: Habitats, Seasonality, Morphology, Production, Nutrient Composition, Heavy Metals, Foodweb Bottleneck. In: Bootsma, Harvey A., Erika T. Jensen, Erica B. Young, and John A. Berges (eds.). Proceedings of a Workshop Held at the Great Lakes WATER Institute, University of Wisconsin-Milwaukee. *Cladophora* Research and Management in the Great Lakes. 43-56.
- Schroeter, S. C., J. D. Dixon, J. Kastendiek, and R. O. Smith. 1993. Detecting the Ecological Effects of Environmental Impacts: A Case Study of Kelp Forest Invertebrates. *Ecological Applications*. 3: 331-350.
- Stevenson, R. Jan, M. L. Bothwell, and R. L. Lowe. 1996. Algal Ecology, Freshwater Benthic Ecosystems: Academic Press.
- Stevenson, R. J. and E. F. Stoermer. 1982. Luxury Consumption of Phosphorus by Five *Cladophora* Epiiphytes in Lake Huron. *Transactions of the American Microscopy Society*. 101: 151-161.
- Stewart-Oaten, A., J. R. Bence, and C. W. Osenberg. 1992. Assessing Effects of Unreplicated Perturbations: No Simple Solutions. *Ecology*. 73: 1396-1404.
- Stewart-Oaten, A. and W. W. Murdoch. 1986. Environmental Impact Assessment: "Pseudoreplication" in Time? *Ecology*. 73: 929-940.
- Suplee, Michael W. 2004. Wadeable Streams of Montana's Hi-Line Region : An Analysis of Their Nature and Condition With an Emphasis on Factors Affecting Aquatic Plant Communities and Recommendations to Prevent Nuisance Algae Conditions. Helena, MT: Montana Department of Environmental Quality, Water Quality Standards Section.
- Suplee, Michael W., Rosie Sada de Suplee, David L. Feldman, and Tina Laidlaw. 2005. Identification and Assessment of Montana Reference Streams: A Follow-Up and Expansion of the 1992 Benchmark Biology Study. Helena, MT: Montana Department of Environmental Quality.
- Suplee, Michael W., Arun Varghese, and Joshua Cleland. 2007. Developing Nutrient Criteria for Streams: An Evaluation of the Frequency Distribution Method. *Journal of the American Water Resources Association*. 43(2): 456-472.
- Suplee, Michael W., V. Watson, M. Teply, and H. McKee. 2009. How Green Is Too Green? Public Opinion of What Constitutes Undesirable Algae Levels in Streams. *Journal of the American Water Resources Association*. 45: 123-140.

- Suplee, Michael W., V. Watson, A. Varghese, and Joshua Cleland. 2008. Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers. Helena, MT: MT DEQ Water Quality Planning Bureau.
- Tepley, M. and Loren L. Bahls. 2005. Diatom Biocriteria for Montana Streams. Larix Systems, Inc. and *Hannaea*.
- Tepley, M. 2010a. Interpretation of Periphyton Samples From Montana Streams. Lacey, WA: Cramer Fish Sciences.
- Tepley, Mark. 2010b. Diatom Biocriteria for Montana Streams. Lacey, WA: Cramer Fish Sciences.
- Tepley, Mark E. and Loren L. Bahls. 2006. Diatom Biocriteria for Montana Streams: Middle Rockies Ecoregion. Helena, MT: Larix Systems, Inc.
- Tetra Tech Inc. 2010. Analysis of Montana Nutrient and Biological Data for the Nutrient Scientific Technical Exchange Partnership Support (N-STEPS).
- U.S. Environmental Protection Agency. 2002. Consolidated Assessment and Listing Methodology: Towards a Compendium of Best Practices. Washington, D.C.: U.S. Environmental Protection Agency.
- U.S. Environmental Protection Agency. 2000. Nutrient Criteria Technical Guidance Manual, Rivers and Streams. Washington, DC: United States Environmental Protection Agency. Report EPA-822-B00-002. <http://www.epa.gov/waterscience/criteria/nutrient/guidance/rivers/index.html>.
- , 2006. Data Quality Assessment: Statistical Methods for Practitioners. Washington, DC: United States Environmental Protection Agency, Office of Environmental Information. Report EPA/240/B-06/003.
- Underwood, A. J. 1994. On Beyond BACI: Sampling Designs That Might Reliably Detect Environmental Change. *Ecological Applications*. 4: 3-15.
- Varghese, A. and Joshua Cleland. 2008. Updated Statistical Analyses of Water Quality Data, Compliance Tools, and Change-point Assessment for Montana Rivers and Streams. Fairfax, VA.
- Varghese, Arun and Joshua Cleland. 2005. Seasonally Stratified Water Quality Analysis for Montana Rivers and Streams: Final Report. Fairfax, VA: ICF Consulting.

DEQ Response to Earthjustice/Potomac and Shenandoah Riverkeepers

Thank you for your comments. The information regarding algal impacts in the Shenandoah River basin submitted during the 2016 Assessment data window was used to classify 5 river segments (7 assessment units) as having an Observed Effect, or Category 3C, on both the 2014 and 2016 Integrated Reports. These waters were prioritized for follow-up monitoring in 2016 and 2017.

DEQ maintains our commitments regarding the development of scientifically sound tools to address water quality impacts due to excess algal growth in the Shenandoah River. Per the April 8, 2016 commitment letter between DEQ and EPA regarding Shenandoah Algae issues, DEQ has made progress toward the development of field estimation methods by conducting extensive monitoring of the Category 3C segments in the Shenandoah during the 2016 and 2017 growing seasons. A summary is available in Chapter 4.3 of Virginia's 2016 Integrated report. DEQ continues to make progress toward the development of impairment thresholds, which will be available for public comment in the 2018 Integrated Report Guidance Manual.